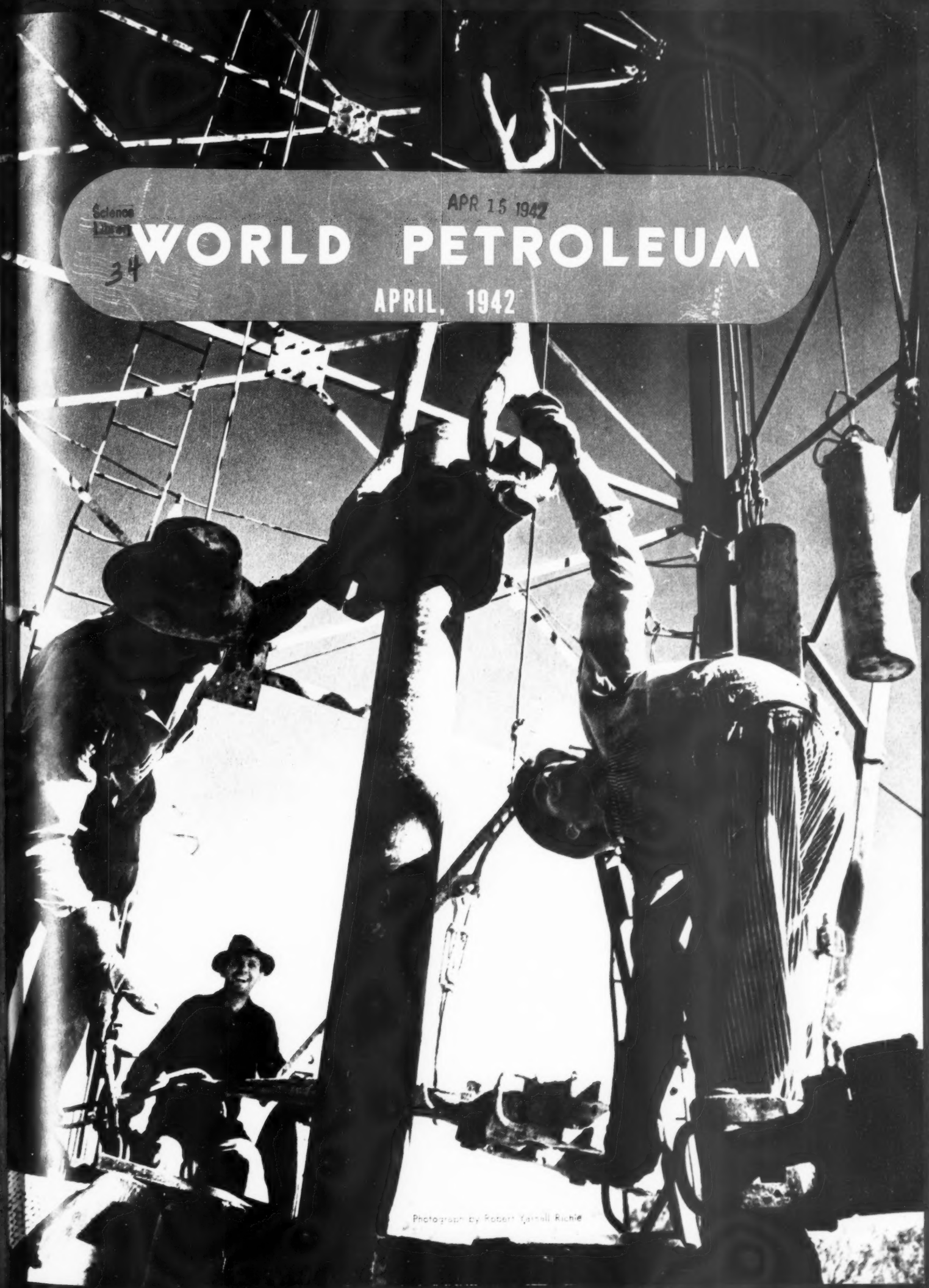
Science Library
APR 15 1942
34

WORLD PETROLEUM

APRIL, 1942



Photograph by Robert Farrell Richie

WE ARE Ready!
Jeeps . . . trucks . . . tanks and planes, will not move without fuel. But we are READY!
With the beginning of a new Industry – Natural Gasoline, Ed Hanlon built his first plant back in 1908. Today, Hanlon-Buchanan is ready with a daily capacity of thousands of barrels of uniform Stabilized Natural Gasoline – STA-VOL-ENE the "Natural" known throughout the World.
STA-VOL-ENE
STABILITY VOLATILITY ENERGY
IT'S A "NATURAL"

Hanlon-Buchanan, Inc

PIONEER NATURAL GASOLINE MANUFACTURER

EXPORT TERMINALS:
Goodhope, La. Corpus Christi, Tex.
Houston, Texas Texas City, Texas
Bartlow, Texas Galena Park, Texas

TULSA, OKLAHOMA
NATIONAL BANK OF TULSA BUILDING
PHONE 4-1101 or L.D. 398 WIRE – OR WRITE P. O. BOX 1559
Cable Address . . . STAVOLENE, Tulsa, U. S. A.

FOREIGN REPRESENTATIVE
Barks, Williams & Co., Ltd.
4 Lloyd's Ave.
London, England

WORLD PETROLEUM

Founded by Russell Palmer

Incorporating Petroleum Equipment Exporter

THE MANAGEMENT PUBLICATION OF THE INTERNATIONAL PETROLEUM INDUSTRY

VOLUME 13 | APRIL, 1942 | NUMBER 4

CONTENTS

Petroleum Industry Mobilized 22

War Program for Refining 26

Axis Attacks Allied Oil Supply 29

Kessler Describes NEI Destruction . . 35

Pressure Maintenance Serves War Economy 36

Geodynamic Prospecting 38

Practical Measures for War Conservation 42

Foreign Oil Legion 44

World Crude Oil Production 46

Abstracts 47

Rex W. Wadman
General Manager

E. W. Mayo
Editor

E. W. Mayo, Jr.
Managing Editor

S. J. Gallay
Advertising Manager

Heyworth Campbell
Art Director

COPYRIGHT

COPYRIGHT, 1942, by the estate of Russell Palmer. Contents may not be reproduced without permission.

CORRESPONDENCE

ADDRESS all correspondence regarding editorial, advertising and subscription matters to 2 West 45th Street, New York, N. Y. Telephone Murray Hill 2-7333.

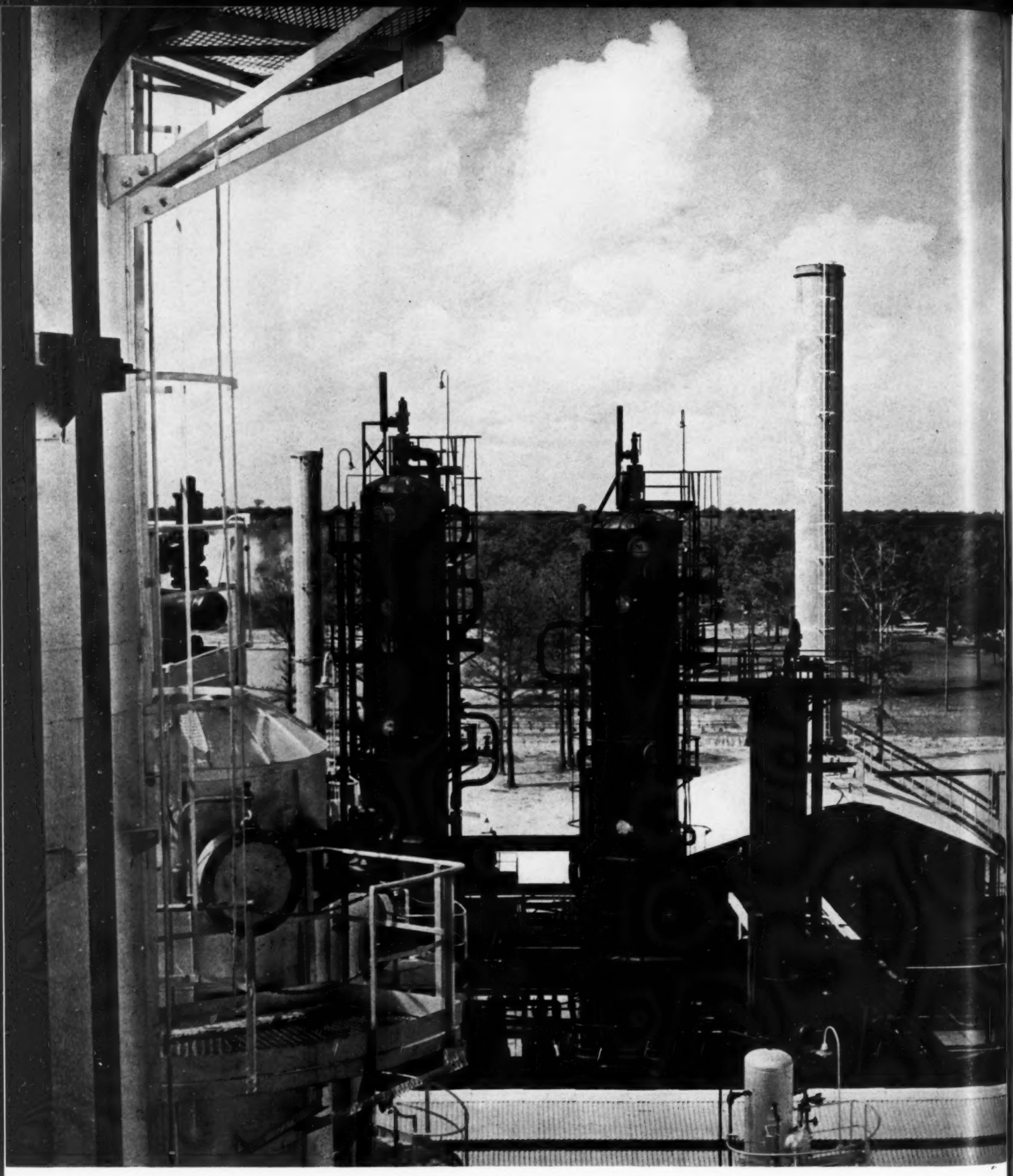
Published monthly by the estate of Russell Palmer, 34 Crystal Street, East Stroudsburg, Pa.

London office: Brettenham House, Lancaster Place, W.C.2.

Pacific Coast office: Don F. Harner, 1595 Pacific Avenue, Long Beach, California. (Tel.: 613-238)

SUBSCRIPTIONS

Annual subscription is offered at the flat rate of $5.00 (U.S.) postpaid. Single copies are obtainable at 50 cents.



A modern mid-continent refinery photographed by Ulric Meisel.

EDITORIAL

CONGRESS SHOULD VALIDATE INDUSTRY COOPERATION

TO oil was credited the victory of the Allies in the first world war. The statement, so often quoted, that they floated to victory on a sea of oil, has long been accepted as a deserved tribute. It may be pointed out, however, that if oil was decisive in the struggle that took place a quarter of a century ago, it has become indispensable in the far greater conflict now raging. Not the heaviest battalions but the most efficient fighting machines backed by the best organized system of transport determine the outcome of today's campaigns. But all this mechanized equipment becomes as useless without oil as it would be if lacking the men to operate it and the missiles it hurls against the enemy.

The American oil industry counts itself fortunate that it was ready to meet the challenge of war despite the unexpectedness with which the challenge came. From the very beginning of the movement toward military preparedness the industry has placed its resources of men, materials, and technical knowledge unreservedly at the service of the government. It met the requests of the Army and Navy for transfer of its facilities to their use, undertook the construction of plants to produce specialized war materials and relegated to the background its own commercial interests wherever the national welfare called for such action. For this, of course, it claimed no special credit since it but followed the course that its members felt should be adopted by all patriotic citizens whatever their occupations.

With the need for an intensified war effort, it became evident that in order to meet the greatly increased demands thereby imposed, oil producers and refiners would have to be asked to pool their resources, exchange products and enter into joint relationships forbidden by the anti trust laws of the country. With prompt recognition of this fact, the Petroleum Coordinator, as one of the early official acts following his appointment, proposed to the Attorney General that whenever he found it necessary in the national interest to ask the petroleum industry to take action which, under normal conditions, might expose the participants to legal attack, the orders relating to such procedure should be submitted to and cleared by officials of the Department of Justice and this method has been followed in numerous instances. The same system prevails in the case of other large businesses where united action may be required.

To the credit of the oil industry be it said that no question of the legality or effectiveness of this arrangement has been permitted to interfere with prompt compliance with every official request that has been put before it. As the war has assumed greater dimensions and the demands for unification of activities have become more frequent and more numerous, the necessity of getting specific authorization from the Department of Justice for every action involving cooperation between two or more oil companies has become somewhat cumbersome, requiring as it does one more step in giving effect to decisions that should be translated quickly into action. Moreover, in the opinion of many able lawyers, there is a question whether the decision of a government official to grant exemption from the provisions of an act of Congress would be binding upon his successor. The section of the law authorizing the bringing of civil suits for triple damages by any persons who feel that they have been injured through contravention of its provisions is completely outside the control of the Department of Justice. It might later be invoked with disastrous effect against industrial companies responding now to the call for joint action as a patriotic service.

While the laws against restraint of competition have been regarded as measures of special protection for small businesses, it has become evident that in the subordination of all other considerations to the demands of war economy, it is the small operator, not only in the petroleum industry but in many others as well, who runs the greatest risk of being put out of business. That this possibility was foreseen by the Petroleum Coordinator is indicated by a passage in his letter to the Attorney General previously referred to in which he said: "It may also be necessary to take action to avoid imposing inequitable burdens upon small independent operators in the present emergency."

It is the place of Congress itself to take the action which will make possible the voluntary union of efforts to serve the nation most effectively in its hour of peril and the voluntary sharing of burdens which otherwise would bear heavily upon those least able to sustain them. Such affirmative action, like other enactments defined as purely war measures, need involve no permanent departure from past policy. It could be limited to the emergency. It would clear the way for the full exercise of industry cooperation during the war and would remove the possibility of unfair prosecution under a different party regime after the time of danger has passed.

William R. Boyd Jr., chairman of the Executive Committee of the Petroleum Industry War Council, photographed at his desk in Washington by Harris & Ewing.

Petroleum Industry Mobilized For SUPREME WAR EFFORT

Through Its War Council and Many Subcommittees, the Industry Is Concentrating Men and Resources on Total Service To Meet Needs of the Nation and Its Allies

LONG BEFORE the shadows of war began to extend over the western world, the American petroleum industry was steadily preparing to serve the nation's needs in the great conflict in which it is now engaged. Year by year, through the expenditure of hundreds of millions of dollars in the search for oil and in the improvement of the methods and machinery of exploration, it was adding to the precious reserves of this most essential war material. Year by year, through other millions spent in research, it was raising its standards, making possible the construction of more powerful and efficient engines, and discovering new products for which no immediate industrial demand existed, but which have acquired first-rank importance under today's conditions. All this was done, of course, as a part of the industry's commercial development, under the spur of competition, and not as a military objective. Nevertheless, it is fortunate for the country and its allies that the oil industry has maintained a progressive spirit and a forward looking attitude that never stopped to count the cost of any improvement that would increase its efficiency or widen the scope of its activities. As a result, it was well prepared to meet the unusual demands that have been put upon it and to make the transition to wartime economy swiftly and effectively.

In the earlier stages of the war, when America was thinking and acting in terms of national defense, the oil industry placed its resources and services unreservedly at the disposal of the government. Its thinking and its preparations were in many respects ahead of the requirements of the situation as they were viewed in official quarters at that time. As the conflict deepened and spread, it became evident that the concentration of oil industry activities upon a war effort of maximum efficiency called for combined action, the pooling of facilities and interchange of supplies in which the members of the industry could not engage under existing federal laws, and that the authority of the national government was necessary to enable the industry to operate as a unit. This authority was extended by the President through creation of the Office of Petroleum Coordinator and the appointment of Secretary of the Interior Ickes as its executive head. Again the members of the industry moved at once to cooperate fully with this new agency which the Coordinator himself described as a partnership between government and industry designed to make possible the accomplishment of ends which neither could attain by working alone. Translating this theory into action, the Coordinator built up an official staff consisting for the most part of practical oil men drawn from the ranks of the industry in all parts of the country.

Carrying further the program of industrial self-regulation under governmental supervision, the Coordinator divided the country into five districts, following as closely as possible the geographic and economic boundaries of the industry's operations. In each district he set up four functional committees: Production, Refining, Transportation, and Marketing. These committees consisted of twelve members each, selected to represent the four functional operations in their districts. Later, a fifth division for Natural Gas and Natural Gasoline was added in each district. Collectively, under a general chairman, the chairmen of these functional committees constitute a general committee for each district.

This arrangement was unique in government control or jurisdiction. It permitted the petroleum industry to meet special war requirements with minimum interference with its regular operations. It required only a limited staff of qualified experts in the Coordinator's Office in Washington to direct the operations and issue the recommendations to the district committees to carry out.

The district committees, composed of outstanding men in the industry and experts in their local fields, bent to the task of discharging their newly acquired responsibility with the vigor characteristic of the oil industry. Geographically the arrangement was highly satisfactory, but in spite of long hours and hard work by the chairmen and members of these committees, they were unable to cope with the ever-increasing problems that were national in character.

The Coordinator, realizing the limitations of this set-up, again called on the industry—this time to a greater and even more far-reaching effect. The outcome was the formation of a centralized agency of the industry—one capable of mobilizing its facilities for the war effort on a national scale. The Petroleum Industry Council for National Defense was the result and the first meeting was called for December 8, 1941—the day following Pearl Harbor. The Council was originally intended to be strictly an advisory body but its work has developed to the point that it is now carrying on many functional activities and its name was changed in February to the Petroleum Industry War Council.

The Council's seventy-two members constitute a representative cross-section of the industry. The general chairman and the chairmen of each of the five functional committees in each district are members. This in itself brings together outstanding leaders in the field of production, refining, transportation, and marketing from the different sections of the country. The Council's set-up, however, goes beyond that and includes the presidents of the fourteen major national and sectional trade associations. These associations, representing the various entities of the petroleum in-

Left to right: Robert H. Colley, chairman of the PIWC Committee on Refining; W. S. Farish, chairman of the PIWC Committee for the Protection of Petroleum Facilities; and, B. L. Majewski, chairman of the PIWC Committee on Marketing.

dustry, such as producers, refiners and marketers, reach out through their memberships to practically every operator, large or small. The organization goes even further by including the presidents of the large integrated and outstanding independent companies and operators. In enlisting the services for the Council of such industrial leaders, the Coordinator took advantage of their advice and counsel and at the same time brought them into closer association with each other to work out and formulate programs leading to one objective—an early and successful consummation of the war. Such men, regardless of their patriotic desires, could not be spared for even part-time service to the government, but their knowledge and experience are made available through their membership on the Council.

It has, therefore, been possible for the Coordinator to obtain promptly the views and reactions of the smallest to the largest producers, refiners, transporters and marketers, with a minimum of effort and at no expense to the government. With such representation the Council, working hand-in-hand with the Coordinator's Office, has every facility for discharging adequately the duty placed upon it by the Coordinator "to see that every barrel of oil that is needed in any part of the world for America's participation in the war is produced and delivered when and where needed."

The Council holds a unique position in that while occupying a place in the official set-up of the Petroleum Coordinator's organization, it is independent in its operations. In its advisory capacity, it submits information and opinions at the request of the Coordinator, but it is not limited to answering such requests. It may submit data and recommendations on any subject that its members regard as important or volunteer services that it may consider useful to the general cause. It is intended to be the voice of the industry and the medium through which measures of cooperation that do not require the issuance of official orders may be carried out.

Meetings of the War Council are held in Washington once a month but for its more convenient functioning, an executive committee of twenty-five, with W. R. Boyd, Jr., president of the Council and of the American Petroleum Institute, as chairman, was appointed. Seven main committees—on Production, Transportation, Refining, Marketing, Natural Gas and Gasoline, Protection of Petroleum Facilities, and Economics—were set up along with a large number of subcommittees to deal with specific problems held to lie within the scope of the Council's field of operations. Office headquarters in the Shoreham Hotel in Washington, in charge of Chairman Boyd and Secretary-Treasurer Allen H. Hand, serve as the clearing house for Council activities.

Much of the important wheel horse work conducted under the auspices of the Council is carried on by the members of these various committees and sub-committees, some of whom are giving their full energies to committee tasks, while others devote to these activities time that they can ill afford to spare from their regular duties Their labors are carried on inconspicuously and receive little mention even within the industry, but their services are highly important in adjusting industry operations to meet the constantly changing conditions and rapidly growing demands of the war situation.

One of the important tasks in maintaining the effective operation of the oil industry, for example, is the protection of fields and structures against damage from direct enemy attack or from sabotage. This work is being carried on under the direction of the Petroleum Industry War Council through its Committee on Protection of Petroleum Facilities, of which W. S. Farish is chairman. In a sense this is not a new activity since the guarding of plants and particularly of oil in storage has been going on since the development of the emergency in 1940. Following the entrance of the United States into the war, this work has been broadened and intensified. While the Army, Navy, and other agencies of government have concerned themselves with certain phases of this problem, the actual work of preventing trespassing, guarding against attack from without or sabotage within, setting up records of employees, maintaining lookouts and organizing to fight fires or meet other emergencies rests with individual companies and operators. To facilitate

Left to right: O. D. Donnell, chairman of the PIWC Committee on Production; Robert E. Wilson, chairman of the PIWC Committee on Economics; and, W. Alton Jones, chairman of the PIWC Committee on Transportation.

Allen H. Hand, Secretary-Treasurer of the Petroleum Industry War Council whose thirty years experience in the petroleum industry led to his selection as chief of the petroleum unit in the Office of Price Administration and later as assistant dire tor of transportation in the OPC.

this work, the national committee has directed its efforts to determining, in cooperation with governmental authorities, the essential safeguards to be applied, bringing about uniformity among the provisions proposed by military and civilian defense officials and informing the members of the petroleum industry of the steps that should be taken to insure protection so far as may be possible for every tank farm, refinery, pipeline system, water terminal, and even smaller units of the industry in every part of the country. Since operating conditions and the degree of protection required vary in different parts of the country, detailed arrangements are in the hands of five regional sub-committees.

As a result of the enemy submarine drive against oil-carrying ships in surrounding ocean waters and the requisitioning of tanker tonnage by the Navy and the Maritime Commission, transportation has become a matter of acute concern for the petroleum industry. While the problems of transportation are largely local and as such are dealt with by the regional industry committees of the Office of Petroleum Coordinator and numerous sub-committees which are very active, particularly in the eastern district, the situation has become one of national significance and it engages the attention of the Transportation Committee of the War Council headed by W. Alton Jones, president of Cities Service Oil Company.

So many factors have combined to upset normal conditions in the marketing division of the oil industry that the Committee on Marketing, of which B. L. Majewski, vice president of Deep Rock Oil Company, is chairman, has set up a number of sub-committees to deal with the different kinds of problems that have been raised. Disruption of the established transportation system, compelling resort to other more expensive means of moving products, has created both operating and financial difficulties for marketers since price ceilings upon their products prevent the passing on of these charges to consumers. Scarcity of materials necessitates changes in containers and equipment used by the industry, while concentration on meeting the specialized demands of the military machine upsets the balance usually maintained between the industry's products.

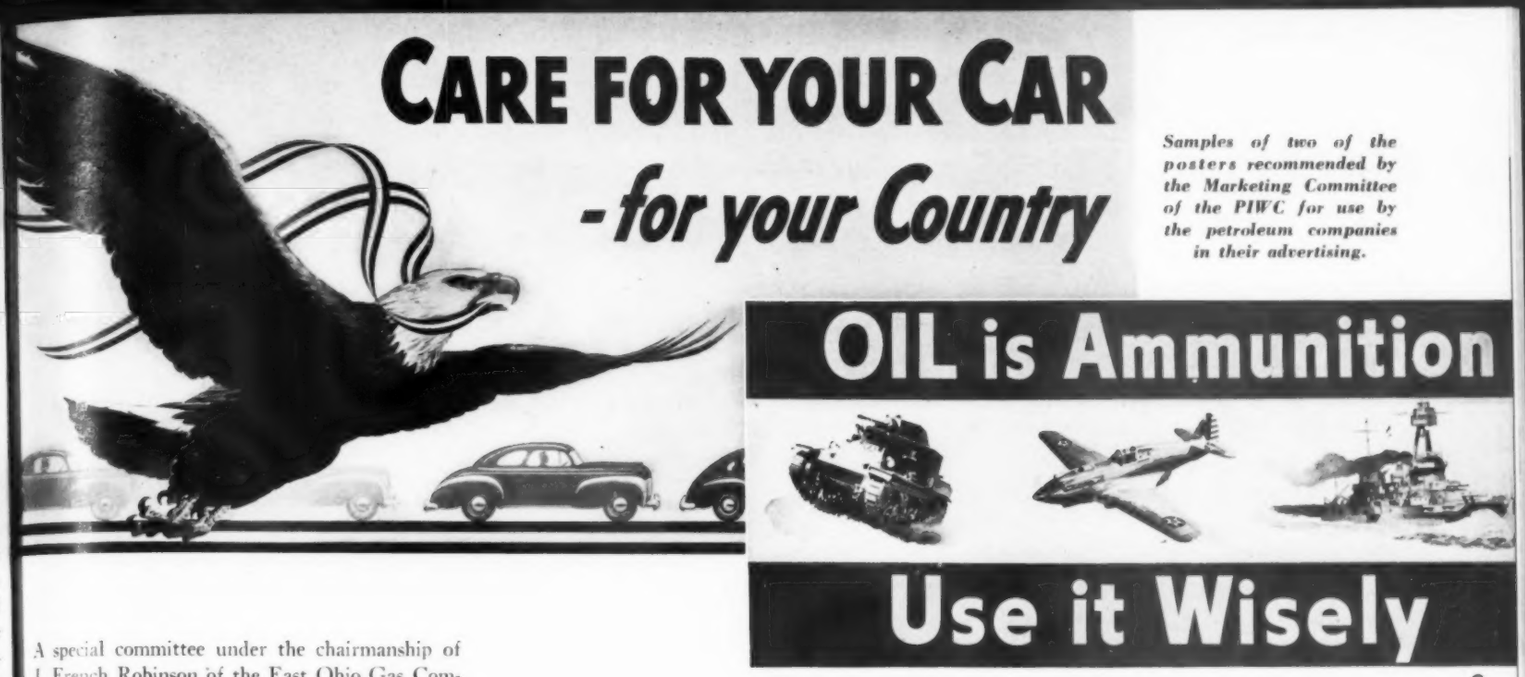
Three sub-agencies of the Committee on Marketing that are engaged on important tasks are the sub-committees on Containers, on Equipment, and on Product Conservation. The container problem is primarily one of materials since the industry is a large user of steel and tin, both of which have become increasingly scarce and increasingly in demand for use in the production of war machines and armament. At the same time, great quantities of petroleum products destined for United States armed forces and for Allied nations receiving aid under Lend-lease require shipment in metal containers for which no readily available substitute has been found. This reduces still further the amount of material that can be applied to domestic uses. Final decision in this matter rests, of course, with the War Production Board but the containers sub-committee of which Lloyd Lochridge of Sinclair Refining Company is chairman, has been of great service in providing information and presenting practical considerations involved in the handling of this subject. Similar conditions affect the provision of equipment urgently needed by the industry and provide the problems that keep the sub-committee on Equipment, of which C. C. Benedict of Socony-Vacuum is chairman, in almost continuous session.

An effective campaign to interest individual consumers of petroleum in the conservation of products was one of the constructive activities quickly launched by a special committee of which W. Alton Jones was Chairman. Its comprehensive preliminary report was approved by the Coordinator and handed back to the Council to be put into effect. A three-man group made up of B. I. Graves, vice-president of Tide Water Associated Oil Company as chairman, W. H. Kershaw of The Texas Company and J. A. Miller of Standard Oil Company of New Jersey, forming a sub-committee to deal with the subject, called to its assistance representatives of company sales and advertising staffs, and these specialists speedily worked out an educational campaign that has been making its influence felt throughout the country for many weeks past. Adopting two selling slogans: "Oil is Ammunition—Use it Wisely" and "Care for Your Car, for Your Country," this committee wisely decided to confine itself to developing various applications of these themes and recommending their adoption by oil companies in their individual publicity campaigns. Prompt acceptance of this suggestion by the oil companies has led to the incorporation of the slogans into company advertisements and radio broadcasts and their display in posters at service stations and in numerous other ways. Tangible results of the millions of messages directed daily to consumers are observable in a marked decrease in unnecessary driving.

In the fields of production and refining, the committees appointed by the Council necessarily work in close relationship with the corresponding divisions of the Office of Petroleum Coordinator in view of the intimate bearing of activities in these fields upon the supply of direct war materials. Specific recommendations have been submitted which are designed to increase output, save time and materials, and to enable the industry to operate with the greatest degree of efficiency in meeting war requirements, and further studies along these lines are under way. The Committee on Refining at the March meeting of the Council introduced a resolution, in view of the shortage of trained technical personnel, that all refineries operate on a minimum forty-hour week and that the industry institute an employee training program. The Committee on Marketing submitted a resolution recommending that rationing of petroleum products be applied only in areas of shortage and that, in order to release manpower for essential war efforts, to save electricity and to facilitate blackouts, operation of service stations be restricted, favoring night closing.

Faced with the realization that adequate crude reserves must be maintained during the emergency, the Council at its first regular meeting formed a special committee, under the chairmanship of O. D. Donnell, president of the Ohio Oil Company, to study ways and means of increasing crude oil reserves, and preventing the premature abandonment of stripper wells. After an exhaustive survey of the situation, this committee reported the following conclusions: (1) That additions to the nation's known oil reserves have shown a declining trend for the past three years; (2) That new reserves are needed in order to meet indicated consumptive demand without waste; (3) That there is an indicated trend of increased abandonment of small wells; (4) That an increased number of wells must be drilled in order to discover the same amount of oil as formerly; (5) That premiums granted discovery wells in the form of increased allowables are an incentive to exploration; (6) That adequate prices of crude oil, which give consideration to overall costs, are essential to exploration incentive and to extend the economic life of small wells; (7) That retention of present statutory percentage depletion allowance is essential to the above objectives.

Because of its importance in the production of 100-octane gasoline, butadiene, and other specialized war materials, natural gasoline has come to occupy a central place in the defense program.



Samples of two of the posters recommended by the Marketing Committee of the PIWC for use by the petroleum companies in their advertising.

A special committee under the chairmanship of J. French Robinson of the East Ohio Gas Company has been assigned to the study of natural gas and gasoline resources and to their utilization for war production. Because of applications of these products to the manufacture of armament, explosives, synthetic rubber and a wide range of chemical products their production and distribution to meet most essential needs offers a broad field of activity for this committee.

A most important function for which no provision was made originally is the study of the ever-changing conditions, the dislocations of normal operations arising from demands for special products such as 100-octane gasoline, toluene, and butadiene and styrene for manufacture of synthetic rubber, for the war efforts, and the future economics of the industry. A Committee on Petroleum Economics of the Council, under the Chairmanship of Dr. Robert E. Wilson, president of the Pan-American Petroleum and Transport Company, has consequently been formed and a large staff of qualified economists, loaned by the industry, is constantly studying these problems which present perhaps the broadest and certainly one of the most important fields of activity for the Council. The function of the committee as defined by Chairman Wilson, is to take a broad overall view of the petroleum situation uninfluenced by purely local considerations, to study the effect of proposed projects and regulations, to equalize burdens, to minimize the effect of unavoidable dislocations and in general to conform to the guiding principle of war economy which demands the utilization of facilities in such ways as to meet essential needs with the greatest efficiency in terms of manpower, materials, transportation and time.

In a preliminary report submitted to the Council at its March meeting, Dr. Wilson listed the following among the subjects to be dealt with:

(1.) Prepare an estimate of military, industrial and civilian requirements for petroleum products for 1942 and 1943. These schedules will constitute the fundamental bases for many other studies and hence it is essential that they be carefully prepared in the light of all available information and that they be kept up to date. (2.) Tabulate the existing and potential sources of supply by regions and with relationship to available crude supplies and by-products needed for military use. (3.) Prepare and present to the Council a supply program to meet estimated requirements, drawing such requirements from those sources which would afford the greatest efficiency in the use of materials, man-power, transportation and time, without adversely affecting the supplies of by-products needed for the war. (4.) Prepare and submit to the Council an analysis of the Western Hemisphere transportation situation with reference to the existing tanker shortage, studying possible remedial measures and the most efficient methods of using new and supplementary facilities. (5.) Analyze estimates of civilian and industrial requirements from the point of view of the necessities of consumption, realizing that petroleum products are essential to millions in the functioning of the war effort. (6.) Analyze the effect of major new projects with the view of comparing with possible alternatives. (7.) Study future dislocations of the industry likely to result from changes in demand as between products and regions, and prepare schedules of action in advance to meet these conditions. (8.) Study the economics of the rubber situation in its effect upon the petroleum industry. (9.) Study the economics of administered prices in their bearing upon operating results and national interests, and explore the possibilities of devising methods for freezing price levels without creating undesirable rigidities in inter-product and inter-regional price relationships.

As may be seen from the above list of topics the committee is undertaking activities which will keep it fully occupied for a long time to come. It is anticipated that other questions will come up for consideration from time to time as the war situation develops and one of the useful services which the Economics Committee may be expected to perform is to keep the combination of effort and nation-wide coordination of facilities required by the existing situation on a sound economic basis so that it may be possible to restore individual initiative after the present crisis.

In this recapitulation of the work of the Petroleum Industry War Council and various agencies it has not been possible to do more than touch briefly upon the principal activities of the main committees while some of the important tasks being performed by hard working sub-committees have not been dealt with at all. Enough has been told, however, to show that the industry, of its own initiative, is devoting itself unstintingly to meeting the demands and sacrifices imposed by the war. The Council appreciates the magnitude of the task imposed upon the oil industry by the war and recognizes that it has been made more difficult by the loss of Malay and Netherlands India with their supplies of oil and rubber. But the Council knows also that the industry has an inspiring record, that it never has faltered in its battle up the difficult path of progress, and that its technicians have surmounted or by-passed numberless obstacles. Fairly fresh in its memory is the recollection that, during World War One, the industry furnished all the petroleum products needed, when they were needed, where they were needed, and the charge of profiteering was never raised against it. The Council knows that the industry did it before and, under wise leadership and in cooperation with government, it will do it again in the larger measure now required.

Expressing the feeling that pervades the industry, W. R. Boyd, Jr., chairman of the Council, said: "In recent years the industry has undergone changes which are kaleidoscopic, but Pearl Harbor revolutionized its position completely. Instead of 'Oil for the Lamps of China,' it will now be 'Juice for Our Jeeps in Japan,' and when the skids are furnished for the vanquished of the final battle, the petroleum industry will supply the axle grease to help the Axis powers slide to an ignominious defeat."

THREE-WAY Refinery Developed For War Production

By Dr. O. W. Willcox

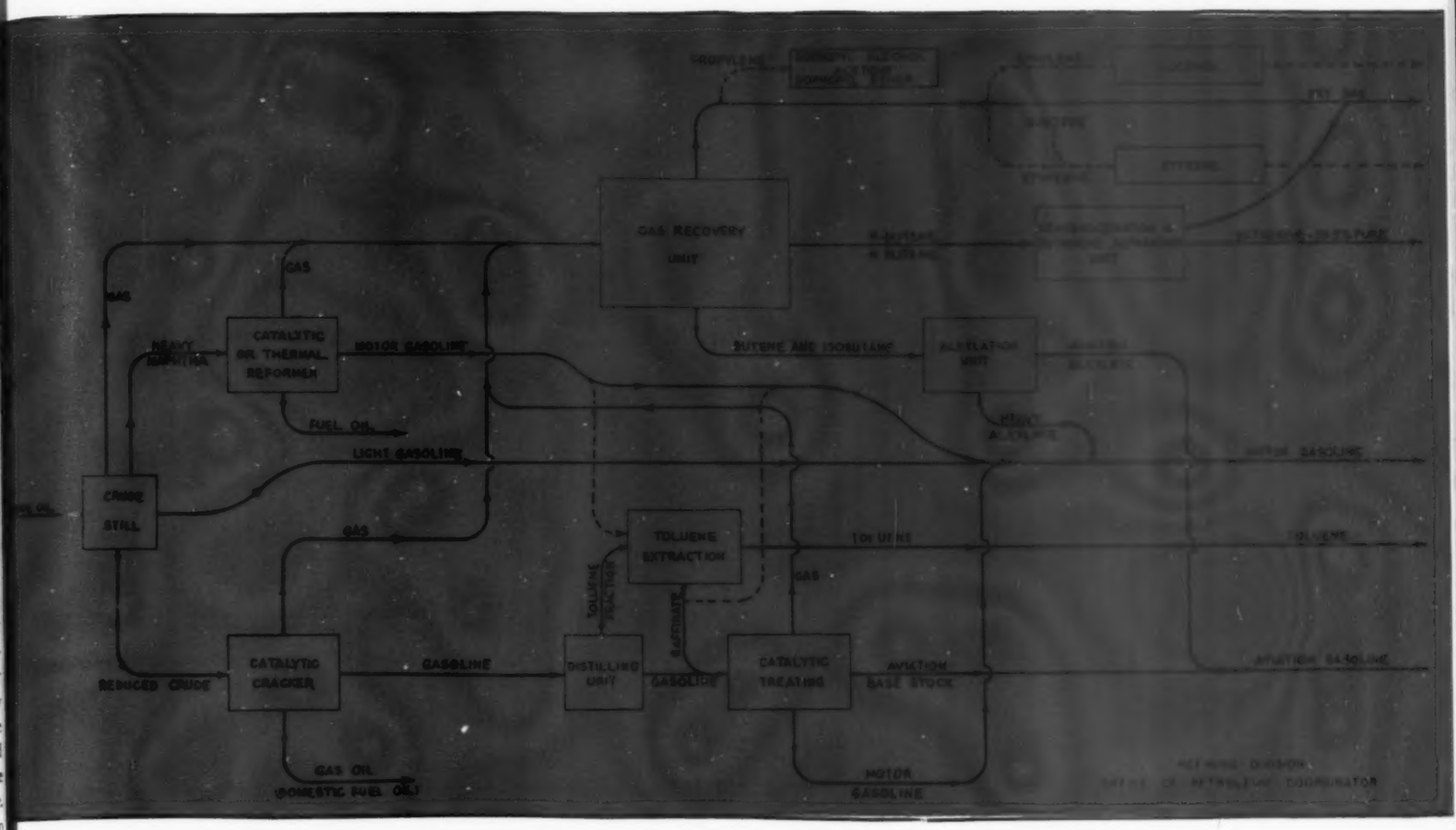
Refining Division of O P C Standardizing on Flexible Design Capable of Producing Butadiene for Rubber, Toluene for Munitions, and 100-Octane Fuel for Planes.

ESTIMATES of the amount of 100-octane-number aviation gasoline that will be required for the flying craft of the Army and Navy have grown almost with every succeeding week since Pearl Harbor. About February 1 of this year the goal stood at 50,000 bbl. a day. By the middle of March the goal was fixed by the O.P.C. at 180,000 bbl., and not long after that most of the talk was about 250,000 bbl. a day as the ultimate wartime requirement.

Although the current production of 100-octane-number aviation gasoline is now well above the 50,000 bbl. mark, the refining industry faces an enormous task in providing the additional facilities required to match the estimated requirements. Provision of these facilities has been stimulated by the government's readiness to sign contracts to buy all the aviation gasoline produced by any refineries that would enlarge their plant facilities for the purpose, either with their own capital or with financial aid from the Defense Supplies Corp. or the Defense Plant Corp. At the time of writing a considerable number of such contracts have been entered into, and more are in process. Practically all of these contracts are with the larger refinery operators who have the funds and other resources to throw into this line. However, the demand is great and the materials most suitable for the manufacture of aviation gasoline are limited in amount and widely scattered. For a number of reasons it is desirable to enlist as many refineries as possible in this production campaign, including the numerous refineries that are classed as small. One difficulty here is that the government has a pressing need for other special products besides aviation gasoline. Toluene for high explosives is one such product and butadiene for artificial rubber is another. Since these other special products are produced from the same raw material that provides the main base for aviation gasoline, it is logical and will be convenient to produce all three in a refinery equipped so that the process will allow the various products to be taken off at appropriate points of the same stream. To be economical, such a "3-way unit" cannot well have a capacity of less than 2,500 bbl. a day and preferably should be built to turn out 5,000 to 10,000 bbl. Not many small refiners would be ready or even able to accept such a commitment. To get around this difficulty, and to put the production of war materials from petroleum on a wide base, the Office of Petroleum Coordinator is evolving a plan that will enable the small refiners to come into the picture. This plan will make it possible for several small refining companies, no one of which would be able to build a plant of the dimensions required for economic operation, to pool their enlarging stocks and build a plant that will be operated for their joint account. According to the plan now in contemplation, the government will agree to buy all the aviation gasoline, toluene and butadiene this cooperative plant can produce, at a price that would liquidate the investment in three years. Such a contract is expected to make it easy to obtain the necessary capital.

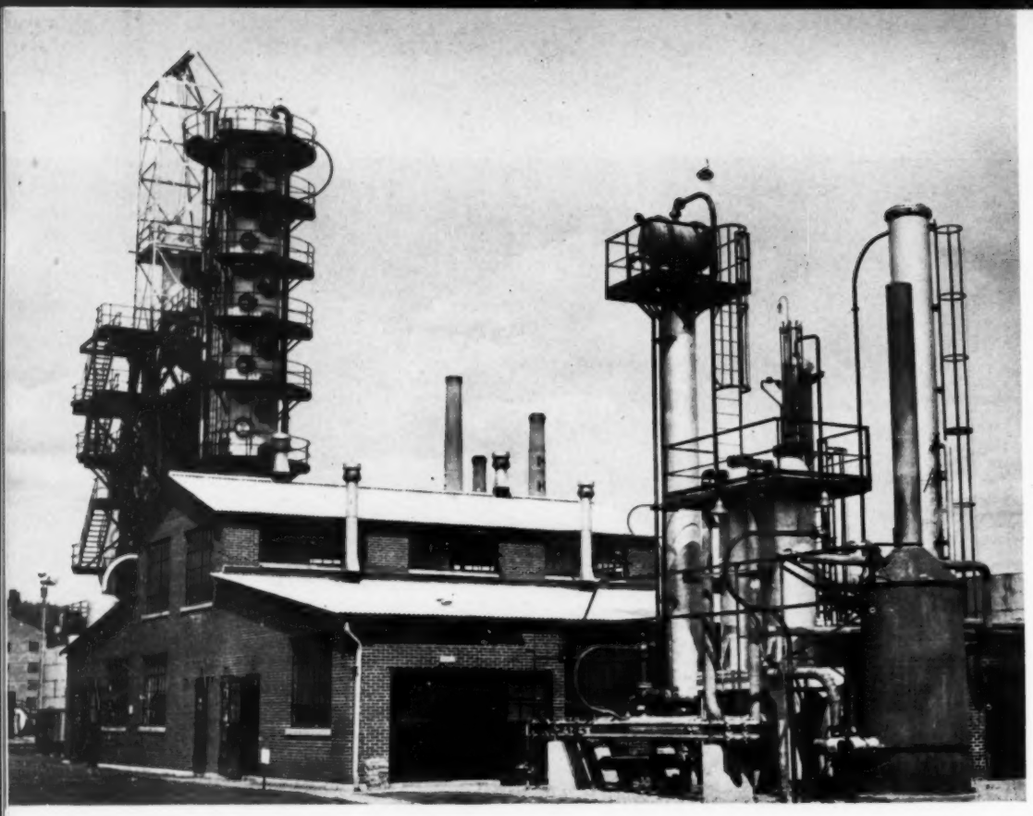
Besides easing the financial aspects of the matter, steps are being taken to solve the technical and engineering problems involved in the construction and operation of these combination units. Experts of several large firms engaged in refinery construction have been collaborating with the Refining Division of the O.P.C., under the general direction of Wright W. Gary. The purpose of this collaboration is to standardize the design so as to reduce construction requirements to a minimum. Complete details of the standard design (which will allow various alternatives to fit special conditions, and aims at flexibility) are at the moment not completely worked out, but in essentials will conform to the scheme of the accompanying diagram, which has been prepared under the direction of C. R. Wagner, Chief of Process Division, O.P.C. Operation of the combination unit will begin when the crude oil enters the crude or topping still. In the ordinary scheme of refinery operation the function of a topping still is to take whatever crude oil comes to hand and merely separate the light gasoline and naphtha fractions from the residue or reduced crude. In a combination unit for the production of 100-octane-number aviation gasoline the topping operation will require unusual attention. In the first place the crudes going to this still will be especially selected for their content of high octane material. This applies especially to certain naphthenic crudes that heretofore have been disesteemed on account of their low content of gasoline. But small as it is (seven to 12 percent) the gasoline fraction of these crudes is rich in high octane material (77-85 o.n.), so that with 15 to 20 percent of isopentane and tetraethyl lead they may be transformed directly into 100 o.n. gasoline without blending with alkylates or other materials. Such crudes are found mostly in California, Louisiana, Oklahoma and Texas: their total volume is relatively not large (estimated by Nelson at 350,000 bbl. a day). Their importance as a military resource has been recognized, and steps have been taken to segregate them for the use of producers of 100 o.n. aviation gasoline. But whatever the kind of crude that comes to this topping still, it will be cut to obtain as much high octane gasoline as possible. Particular care will be taken to obtain all the isopentane which is one of the indispensable base materials for 100 o.n. gasoline. There will also be no more wasting of the butanes, which have now acquired an importance equal to if not superior to that of isopentane. Naturally, the sharpness of these light cuts will be modified to suit the refiner's general purposes and the requirements imposed by the characteristics of the crude petroleum.

A U.O.P. catalytic polymerization unit of large volume in a western refinery: catalytic polymerization is an important component of the proposed three-way plant.



A simplified flow chart prepared by the Refining Division of the Office of the Petroleum Coordinator, suggesting a standard design for proposed combination units to produce aviation gasoline, butadiene for synthetic rubber and toluene for munitions. Where operations of a single refiner are not large enough to justify the erection of the optimum capacity three-way plant, it has been suggested that several smaller refiners combine to construct and operate such a unit. The proposed standard design may be adapted to varying conditions, having been designed with the need for flexibility constantly in mind.

Every existing refinery, whether or not it specializes in aviation gasoline or produces ordinary motor fuel, has a topping still. It is not contemplated that a topping plant will be installed at every one of these combination 3-way units, in particular not at the new units that are to be built and operated for the joint account of several small refiners who are not in a position to install this kind of unit on their own premises. The idea is for these refiners to pool their reduced crudes, naphthas and alkylation materials and deliver them to the combination plant. In that case the initial or front units of the combination plant will be a catalytic cracker for the reduced crudes and a catalytic or thermal reformer for the naphthas. Each member of the association or corporation will receive credit for his deliveries, and share pro rata in the cash proceeds and the by-products on a mutually satisfactory basis. On the diagram the more or less heavy naphtha fraction from the topping stills is shown going to a reforming unit. This unit may be of the conventional thermal type, or of a modern catalytic design, preferably the latter, of which there are several types now available and others that have lately come or are coming through the pilot plant stage. In this connection the well-known Houdry reforming unit comes into consideration. Also the established U.O.P. catalytic process which is designed to convert pentanes, hexanes and heavier to high octane-number isomers that will be segregated for the aviation gasoline base stock. A recent process for isomerizing debutanized cuts from straight run gasoline is a new one offered to the industry by the M. W. Kellogg Company. The products produced by this reformer will, of course, vary in characteristics, depending upon the composition of the charge, the type of reforming unit used, and the conditions under which the reforming operation is conducted. As for these operating conditions, they will be regulated so as to promote the general object of the plant, which is to obtain a good yield of the ingredients of high octane fuel. The reduced crude from the topping still is shown going to a catalytic cracking unit. This may be of the Houdry type, which is more productive of octane values than ordinary thermal cracking. Another catalytic cracking process that is being installed in a number of refineries is one that uses a fluid catalyst; no technical details of this process have been allowed to become public. In any case, the products of the operation are more or less gas, gasoline and gas oil or domestic fuel oil. The last mentioned products are of no interest to the government, which will pay only for the aviation gasoline, toluene, and butadiene produced by the unit, and it will be returned pro rata to the contributing refiners for such use as they can make of it. The gas produced in this cracking unit, together with gas from the catalytic or thermal reforming unit, will go to the gas recovery unit to be stripped of all components that have military value. These include products that for lack of a market are usually wasted with the dry gas, such as propylene which might be collected for use in manufacturing useful chemicals, and ethylene, which has acquired a special importance as one of the raw materials of the styrene that is essential in the manufacture of artificial rubber. The propylene might be converted into polymer or transformed into isopropyl ether, which is an excellent blending agent for high octane gasoline; but perhaps the simplest disposal of it will be to mix it with isopropane or isobutane and send it to the alkylation unit, where it will contribute to the yield of alkylate for blending. It will be noted that the diagram shows the presence of a styrene unit in the combination plant, in which ethylene and benzene will be combined to make styrene which, together with butadiene, constitutes the raw material base for the principal branch of the artificial rubber industry. This introduces the



Catalytic polymerization in the East: development to commercial operation of this Dubbs process has simplified the standardization of a flexible design for the war refining program.

complication of a supply of benzene, which may be obtained from the outside, or produced by a close fractionation of the aromatics contained in the toluene cut. Whether to include this styrene unit will be a matter to be settled in the individual case. Being an olefin ethylene (like propylene) it can be more or less readily alkylated.

Very particular attention will have to be bestowed on the operation of the gas recovery unit with accurate control of temperatures and pressures so as to obtain the maximum yield of the butanes and butenes. It will mean close fractionation. This will have to be accomplished by the use of debutanizing equipment, details of which are not shown on the diagram. In the gas recovery unit the refiner will naturally make such separations of the various hydrocarbons as his requirements may dictate. As mentioned above, complete utilization of the gases would require separation of the propylene and ethylene. The C_4 cut is shown as being split into two fractions, one containing normal butane with or without butene-2, while the other fraction contains isobutane, isobutene, butene-1 and possibly butene-2. The fraction containing normal butane goes to a dehydrogenating unit along with some butene-2, where the mixture is dehydrogenated to produce butadiene for the use of the artificial rubber manufacturers. This unit is equipped and operated so as to produce practically pure butadiene (99.5 percent). The other fraction of the C_4 cut, containing isobutane, goes to an alkylation plant, where alkylate is produced for the manufacture of 100 o.n. gasoline. The residue from the alkylation unit, known as heavy alkylate, may be blended to make ordinary motor fuel, or to produce a "safety fuel" for aviation use (if there is a demand for such a product). At present the most used alkylation process employs sulphuric acid as catalyst. Several new processes, which are said to be more advantageous, are about to be commercialized. While the intention is to standardize the design, it is obvious that there will be room for numerous variations in its operation. The production of butadiene may be increased by flowing additional supplies of butene-2 to the dehydrogenation unit, thereby cutting down on the production of aviation alkylate. (Outside supplies of butane for the dehydrogenator may be procured from the floating supply of this hydrocarbon collected from natural gasoline plants and gas and oilfield separators). The output of butadiene may also be increased by converting ethylene to ethyl alcohol, which would then be converted to butadiene by a catalytic process. Although this disposal of the ethylene would increase the output of butadiene without affecting the output of aviation alkylate, it represents an extension which the smaller plants may not wish to undertake. On the other hand, the production of alkylate may be increased by taking all the available butene-2 to the alkylation unit, and by bringing in outside isobutane in order to alkylate the propylene from the gas stream. Again, the production of aviation blending naphtha may be increased by shutting down the production of toluene and throwing all of the available cuts from the reforming unit and the catalytic treating unit into aviation blending naphtha.

In the meantime the gasoline stream from the catalytic cracking unit will be sent to a distilling column and fractionated to produce a "heart cut" containing toluene, which is shown going to the toluene extraction unit. To this same extraction unit will be delivered the reformed gasoline from the reforming unit, depending on the toluene content of the reformed gasoline, which again depends somewhat on the type of reformer. The toluene extraction may work according to the azeotropic distillation process, or distillation with methanol, or the toluene may be extracted with sulphur dioxide or phenol. The raffinate from the toluene extraction unit, together with the remainder of the catalytically cracked gasoline, is shown going to a catalytic treating unit. The purpose of this unit is to reduce gum content, improve stability, reduce olefin content as well as to improve octane number. After passing a debutanizer (not shown) the treated distillate is fractionated into two cuts, one of which becomes aviation blending stock, and the other goes to motor fuel, which will have a high octane number and other characteristics of a safety fuel (if such is desired). Although not shown on the flow sheet, it is obvious that fractions on either side of the toluene cut might well go to aviation naphtha. Where thermal cracking equipment is available or the domestic fuel oil business does not require the product, the gas oil from the catalytic cracking unit may easily be charged to the thermal cracking equipment with the production of motor fuel as well as additional supplies of gases for the gas recovery unit. By operating such a thermal cracking unit under low pressure and very high temperature, quite appreciable quantities of desirable unsaturated gases may be produced. The plans for this standardized three-way unit have not quite advanced to the point of specifying the exact type of each component unit. There are a number of types to select from. The technologists will have to choose those that are known to produce maximum values in octanes, toluene, and the all-important C_4 hydrocarbons, not overlooking isopentane. There is room for difference in emphasis to be placed on various components of the three-way unit. For instance, certain of the newer catalytic isomerization processes yield an "isomate" that is particularly rich in octanes. As this process is said to be less expensive than the current alkylation process the importance of the alkylation unit may be diminished. In the opinion of the experts of the O.P.C., with the equipment as here laid out it will be possible to attain great flexibility; the production of motor gasoline may be reduced to almost negligible proportions or raised to an ultimate maximum. Such flexibility of operation will be a valuable asset at such a time as this, when the demand for motor gasoline is decreasing and the requirements for butadiene, toluene, aviation gasoline and hydrocarbon chemicals are rapidly expanding.

The aviation gasoline turned out at these plants will be compounded of isopentane, high octane aviation base stock, alkylate and tetraethyl lead. The proportions of these ingredients will depend on what is necessary to make a 100-octane fuel that will meet the specifications as to volatility, etc. The higher the octane value of the "isomate" produced in the catalytic treater, the smaller will be the quantity of alkylate needed.

Axis Launches Desperate Offensive at Allied Oil Sources

By Walter Levy

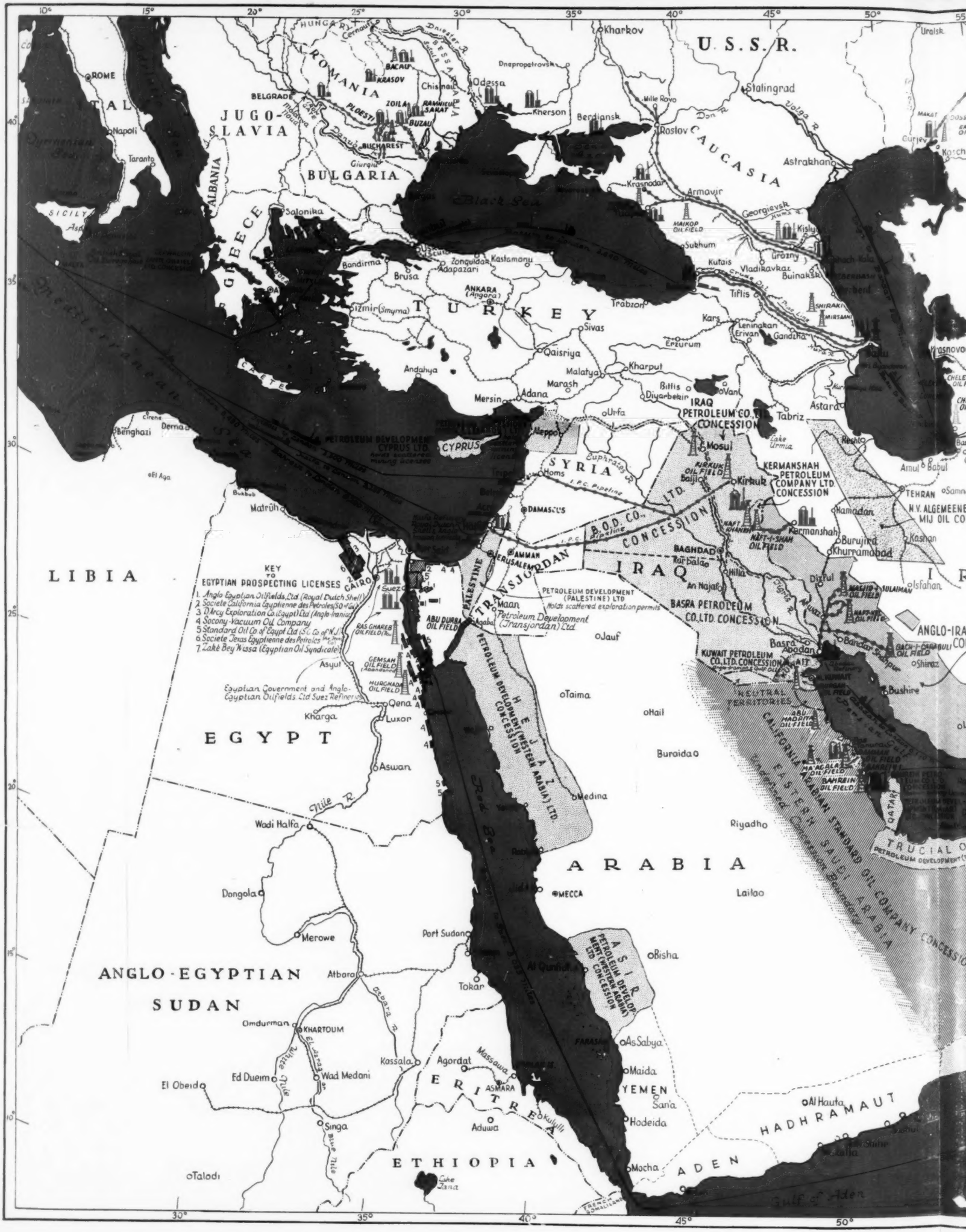
Leading into the uncertain future, Persian pipelines carry crude to the world's largest refinery at Abadan which may soon be the objective of a violent Nazi drive; photo by British Combine.

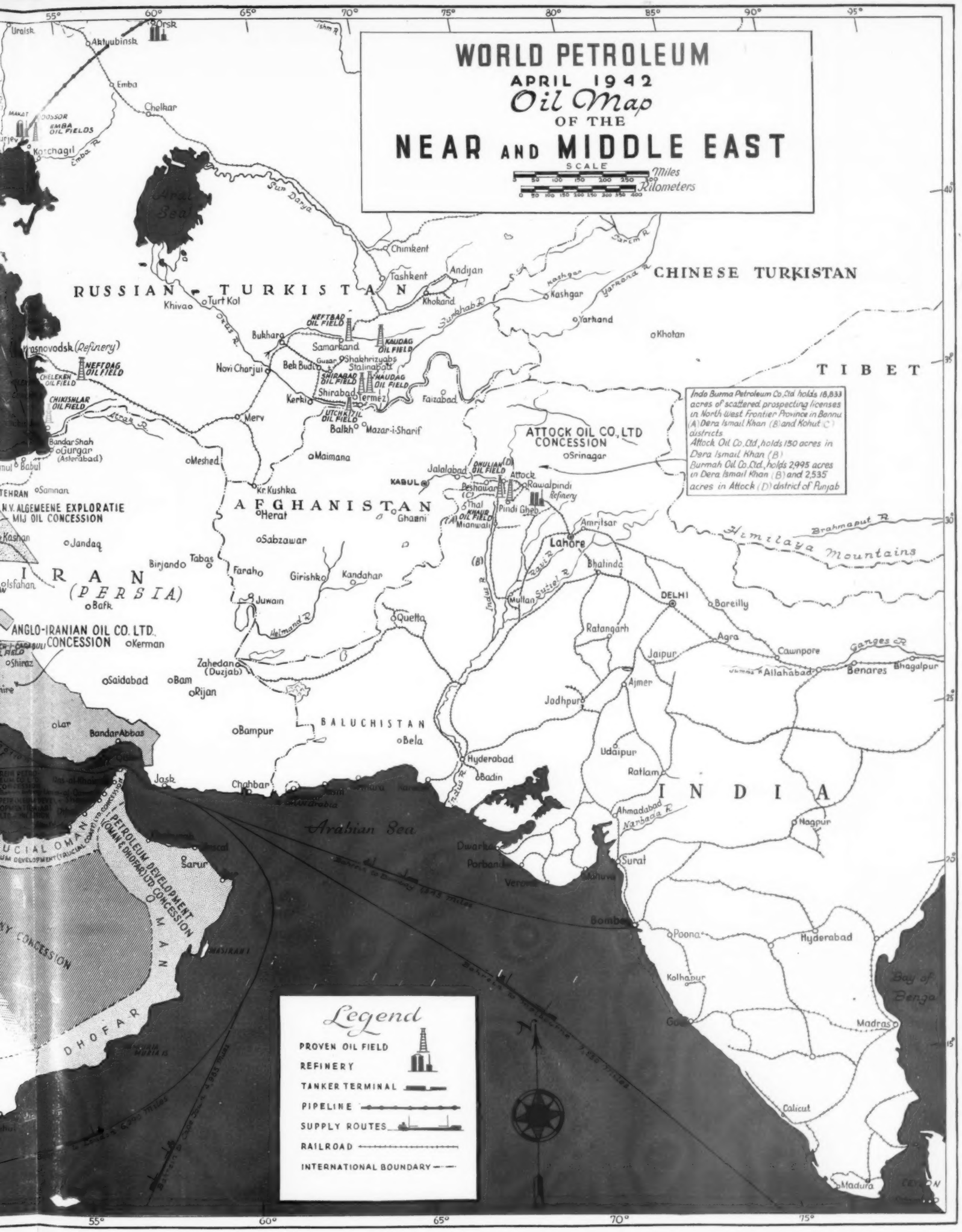
As the pattern of the war unfolds more clearly it becomes increasingly evident that not only the Axis powers, but also the United Nations are confronted with a formidable oil problem. While discussion heretofore has centered largely on a possible shortage in Axis countries, too little attention apparently has been devoted to their aggressive oil strategy which aims at depriving the Allies of oil superiority.

As the Axis powers set out on their path of conquest and tried to solve their immediate oil problem by occupation of nearby oil producing countries such as Poland and Rumania, they deprived Allied and neutral states of a relatively small part of their former sources of supply. But Axis ambitions are not confined to assuring themselves of a safe and uninterrupted flow of oil for their own operations. They are also actively engaged in an offensive warfare against Allied oil supplies. This warfare plays an important role in their strategy and in their master plan for wining the war. Of the independent Allied nations, Great Britain, China, Australia, New Zealand, and the whole of Africa, except Egypt, are without any domestic oil worth mentioning. India and Burma cover only half of their peacetime demand, and with the exception of the small Sakhalin production, Russia's entire Far Eastern territory must be supplied from the Caucasus, the Urals, or by imports from the United States. In such a situation Axis strategy has followed an obvious course. If Hitler and his confederates could stop the regular flow of oil to the Allied nations they would be able not only to neutralize the potential superiority of their opponents in airplanes, tanks and other machines of war, but could dislocate their industrial and transport system from which that future superiority must come. Since the entry of the United States into the war such a strategy must have appealed to the Axis leaders even more strongly. They might not be able to compete successfully with the American industrial machine once it was concentrated on war production. But if the war is being fought far outside the main petroleum producing areas war machines are useless unless sufficient oil for continuous operation is available.

It is not only the interruption of sea communications between the various Allied possessions on which the Nazis and Japanese count. The distribution of oil resources over the world gives them, so they think, a chance to impede or even to stop the flow of oil from producing areas now under Allied control. This would, as they estimate, vastly increase the transport problem by compelling the Allies to ship oil to their possessions from distant producing centers. Until America's entry into the war in December 1941 the Allies obtained their oil from three main producing areas: First the Western Hemisphere (especially the United States, Northern South America and the Dutch West Indies), with output of 1,761,756,000 bbl., and a refining capacity of 1,990,000,000 bbl., corresponding respectively to 78 percent and 73 percent of the world's total. Second, the Near and Middle East, including Persia, Iraq, Egypt, Bahrein, Saudi Arabia, and the Russian Caucasus, with a production of 312,060,000 bbl., and a refining capacity of 360,000,000 bbl., corresponding respectively to 13 percent and 13 percent of the world's total. Third, the Far East, comprising the Dutch East Indies, British Borneo, India and Burma and the Russian part of Sakhalin, with an aggregate output of 82,326,000 bbl. and a refining capacity of 83,000,000 bbl., corresponding respectively to four percent and three percent of the world's totals. What remained in natural oil resources was the small production in Axis controlled countries, mainly Rumania, Germany, Poland, etc., with an output of 56,159,000 bbl., and a refining capacity of 210,000,000 bbl., corresponding respectively to two percent and eight percent of the world's total. We may mention in passing that the large excess refining capacity of the Axis would enable it to treat crude oil from conquered oilfields even if the refineries in or near those fields had been destroyed. When the Allies change from a defensive to an offensive strategy, the Axis oilfields and oil installations, small as they are in world terms, will constitute one of the most important objectives for Allied attacks, the destruction of which may well nigh immobilize the enemy.

We may perhaps classify the first area, the Western Hemisphere, as a "safe" area which will always remain in Allied possession, though attacks by shelling from enemy vessels similar to that directed recently at the Aruba refinery and at California oil installations, by airplanes or by fifth column activity, must always be expected. The most daring and surprising means will doubtless be used to attempt the destruction of some key installations or interruption of operations. But the main efforts of the Axis to interfere with the oil supplies from the Western Hemisphere will be concentrated on the disruption of supply lines as exemplified by the sinking of more than a score of tankers off the East Coast of the United States. It is interesting to note that one of the foremost German oil experts, Dr. Ferdinand Friedensburg, mentioned in a recent book on "Oil in the World War," that in the struggle of 1914 to 1918, the German General Staff devoted insufficient attention to Allied oil supplies. The Gulf of Mexico, he pointed out, would have been one of the most fruitful hunting grounds for submarines which


U.S.S.R.
Kharkov
Uralsk
Stalingrad
Rostov
Berdiansk
Kherson
Odessa
Dnepropetrovsk
Mile Rovo
Volga R.
Don R.
CAUCASIA
Astrakhan
Krasnodar
Armavir
Georgievsk
Grozny
Sukhum
Kutais
Vladikavkaz
Buinaksk
Tiflis
Trabzon
Kars
Leninakan
Erivan
Gandzha
Erzurum
Sivas
Kastamonu
Zonguldak
Adapazari
Bandirma
Brusa
ANKARA (Angora)
Izmir (Smyrna)
TURKEY
Qaisriya
Malatya
Kharput
Bitlis
Diyarbekir
Van
Mersin
Adana
Andahya
Urfa
Aleppo
Tabriz
Astara
Lake Urmia
Reshto
Mosul
IRAQ PETROLEUM CO. LTD. CONCESSION
KERMANSHAH PETROLEUM COMPANY LTD CONCESSION
Kirkuk
Baiji
KIRKUK OIL FIELD
Homs
I.P.C. Pipeline
SYRIA
CYPRUS
PETROLEUM DEVELOPMENT CYPRUS LTD.
Benghazi
Derna
Cirene
El Aga
Bukbub
Matrûh
LIBIA
DAMASCUS
B.O.D. CO. LTD. CONCESSION
AMMAN
JERUSALEM
PALESTINE
TRANSJORDAN
Maan
Aqabah
Petroleum Development (Transjordan) Ltd.
PETROLEUM DEVELOPMENT (PALESTINE) LTD
Holds scattered exploration permits
BAGHDAD
Kut el Amara
Hilla
An Najaf
Jauf
IRAQ
BASRA PETROLEUM CO. LTD. CONCESSION
Dizful
Isfahan
Khurramabad
Burujird
Kashan
Hamadan
Kermanshah
NAFT-I-SHAH OIL FIELD
NAFT KHANEH
TEHRAN
N.V. ALGEMEENE MIJ OIL CO
Amul
Babul
Basra
Abadan
Bandar Shapur
KUWAIT PETROLEUM CO. LTD. CONCESSION
KUWAIT OIL FIELD
Shiraz
Bushire
NEUTRAL TERRITORIES
ABU HADRIYA OIL FIELD
HAJALA OIL FIELD
BAHREIN OIL FIELD
QATAR
TRUCIAL O
PETROLEUM DEVELOPMENT
CALIFORNIA EASTERN ARABIAN STANDARD OIL COMPANY CONCESSION
Buraida
Riyadho
Hail
Taima
Medina
MECCA
Lailao
ARABIA
Red Sea
HEJAZ PETROLEUM DEVELOPMENT (WESTERN ARABIA) LTD. CONCESSION
ASIR PETROLEUM DEVELOPMENT (WESTERN ARABIA) LTD. CONCESSION
Al Qunfida
Bisha
As Sabya
Maida
YEMEN
San'a
Hodeida
Mocha
Al Hauta
HADHRAMAUT
Shihr
Mukalla
ADEN
Gulf of Aden
FRENCH SOMALILAND
Jibuti
Massawa
ASMARA
ERITREA
Aduwa
Kulullu
Agordat
Kassala
Tokar
Port Sudan
Atbara
Berber
Dongola
Merowe
Wadi Halfa
Nile R.
Aswan
Luxor
Qena
Kharga
EGYPT
ANGLO-EGYPTIAN SUDAN
Omdurman
KHARTOUM
Blue Nile R.
White Nile R.
Wad Medani
Ed Dueim
El Obeid
Singa
ETHIOPIA
Talodi
Lake Tana
Gebera R.
Farasan
Suez
CAIRO
Asyut
Egyptian Government and Anglo-Egyptian Oilfields Ltd Suez Refineries
RAS GHAREB OIL FIELD
ABU DURBA OIL FIELD
GEMSAH OIL FIELD (Abandoned)
HURGHADA OIL FIELD
KEY TO EGYPTIAN PROSPECTING LICENSES
1. Anglo Egyptian Oilfields Ltd (Royal Dutch Shell)
2. Societe California Egyptienne des Petroles S.O. of Cal.
3. D'Arcy Exploration Co (Egypt) Ltd (Anglo-Iranian)
4. Socony-Vacuum Oil Company
5. Standard Oil Co of Egypt Ltd (S. Co. of N.J.)
6. Societe Texas Egyptienne des Petroles Inc. Texas Co.
7. Zaki Bey Wissa (Egyptian Oil Syndicate)
ROME
Napoli
Taranto
SICILY
ITALY
Tyrrhenian Sea
Ionian Sea
Adriatic Sea
Aegean Sea
Black Sea
Sea of Marmara
Dardanelles
Bosporus
Mediterranean Sea
ALBANIA
GREECE
Salonika
BULGARIA
JUGO-SLAVIA
BELGRADE
Danube R.
Giurgiu
BUCHAREST
PLOESTI
ZOILA
RAMNICUL SARAT
BUZAU
KRASOV
BACAU
Chisinau
Dniester R.
Prut R.
Bessarabia
Moldavia
ROMANIA
HUNGARY
Cernauti
MAIKOP OIL FIELD
Georgievsk
Kislu
Grozny
Buinaksk
SHIRAKI
MIRSAANI
Krasnovo
CHELEKEN OIL FIELD
Baku
Caspian Sea
Kura R.
Caucasus Mts.
Kuban R.
Makat
Guriev
Kosch
Ural R.
Volga R.
Don R.
Sea of Azov
Crimea
Sevastopol
Yalta
Feodosia
Kerch
Taman
Novorossisk
Tuapse
Sochi
Batum
Poti
Suchum
Kutais
Vladikavkaz
Ossetia
Georgia
Armenia
Azerbaijan
Turkmenistan
Kazakhstan
Uzbekistan
Caspian Sea
Aral Sea
Lake Urmia
Lake Van
Euphrates R.
Tigris R.
Persian Gulf
Gulf of Oman
Strait of Hormuz
Strait of Bab el Mandeb
Red Sea
Gulf of Aqaba
Gulf of Suez
Suez Canal
Nile Delta
Libyan Desert
Arabian Desert
Nubian Desert
Sahara
Tropic of Cancer
Equator
10°
15°
20°
25°
30°
35°
40°
45°
50°
55°
60°
65°
70°
75°
80°
85°
90°
95°
100°
105°
110°
115°
120°
125°
130°
135°
140°
145°
150°
155°
160°
165°
170°
175°
180°
185°
190°
195°
200°
205°
210°
215°
220°
225°
230°
235°
240°
245°
250°
255°
260°
265°
270°
275°
280°
285°
290°
295°
300°
305°
310°
315°
320°
325°
330°
335°
340°
345°
350°
355°
360°
365°
370°
375°
380°
385°
390°
395°
400°
405°
410°
415°
420°
425°
430°
435°
440°
445°
450°
455°
460°
465°
470°
475°
480°
485°
490°
495°
500°
505°
510°
515°
520°
525°
530°
535°
540°
545°
550°
555°
560°
565°
570°
575°
580°
585°
590°
595°
600°
605°
610°
615°
620°
625°
630°
635°
640°
645°
650°
655°
660°
665°
670°
675°
680°
685°
690°
695°
700°
705°
710°
715°
720°
725°
730°
735°
740°
745°
750°
755°
760°
765°
770°
775°
780°
785°
790°
795°
800°
805°
810°
815°
820°
825°
830°
835°
840°
845°
850°
855°
860°
865°
870°
875°
880°
885°
890°
895°
900°
905°
910°
915°
920°
925°
930°
935°
940°
945°
950°
955°
960°
965°
970°
975°
980°
985°
990°
995°
1000°
1005°
1010°
1015°
1020°
1025°
1030°
1035°
1040°
1045°
1050°
1055°
1060°
1065°
1070°
1075°
1080°
1085°
1090°
1095°
1100°
1105°
1110°
1115°
1120°
1125°
1130°
1135°
1140°
1145°
1150°
1155°
1160°
1165°
1170°
1175°
1180°
1185°
1190°
1195°
1200°
1205°
1210°
1215°
1220°
1225°
1230°
1235°
1240°
1245°
1250°
1255°
1260°
1265°
1270°
1275°
1280°
1285°
1290°
1295°
1300°
1305°
1310°
1315°
1320°
1325°
1330°
1335°
1340°
1345°
1350°
1355°
1360°
1365°
1370°
1375°
1380°
1385°
1390°
1395°
1400°
1405°
1410°
1415°
1420°
1425°
1430°
1435°
1440°
1445°
1450°
1455°
1460°
1465°
1470°
1475°
1480°
1485°
1490°
1495°
1500°
1505°
1510°
1515°
1520°
1525°
1530°
1535°
1540°
1545°
1550°
1555°
1560°
1565°
1570°
1575°
1580°
1585°
1590°
1595°
1600°
1605°
1610°
1615°
1620°
1625°
1630°
1635°
1640°
1645°
1650°
1655°
1660°
1665°
1670°
1675°
1680°
1685°
1690°
1695°
1700°
1705°
1710°
1715°
1720°
1725°
1730°
1735°
1740°
1745°
1750°
1755°
1760°
1765°
1770°
1775°
1780°
1785°
1790°
1795°
1800°
1805°
1810°
1815°
1820°
1825°
1830°
1835°
1840°
1845°
1850°
1855°
1860°
1865°
1870°
1875°
1880°
1885°
1890°
1895°
1900°
1905°
1910°
1915°
1920°
1925°
1930°
1935°
1940°
1945°
1950°
1955°
1960°
1965°
1970°
1975°
1980°
1985°
1990°
1995°
2000°
2005°
2010°
2015°
2020°
2025°
2030°
2035°
2040°
2045°
2050°
2055°
2060°
2065°
2070°
2075°
2080°
2085°
2090°
2095°
2100°
2105°
2110°
2115°
2120°
2125°
2130°
2135°
2140°
2145°
2150°
2155°
2160°
2165°
2170°
2175°
2180°
2185°
2190°
2195°
2200°
2205°
2210°
2215°
2220°
2225°
2230°
2235°
2240°
2245°
2250°
2255°
2260°
2265°
2270°
2275°
2280°
2285°
2290°
2295°
2300°
2305°
2310°
2315°
2320°
2325°
2330°
2335°
2340°
2345°
2350°
2355°
2360°
2365°
2370°
2375°
2380°
2385°
2390°
2395°
2400°
2405°
2410°
2415°
2420°
2425°
2430°
2435°
2440°
2445°
2450°
2455°
2460°
2465°
2470°
2475°
2480°
2485°
2490°
2495°
2500°
2505°
2510°
2515°
2520°
2525°
2530°
2535°
2540°
2545°
2550°
2555°
2560°
2565°
2570°
2575°
2580°
2585°
2590°
2595°
2600°
2605°
2610°
2615°
2620°
2625°
2630°
2635°
2640°
2645°
2650°
2655°
2660°
2665°
2670°
2675°
2680°
2685°
2690°
2695°
2700°
2705°
2710°
2715°
2720°
2725°
2730°
2735°
2740°
2745°
2750°
2755°
2760°
2765°
2770°
2775°
2780°
2785°
2790°
2795°
2800°
2805°
2810°
2815°
2820°
2825°
2830°
2835°
2840°
2845°
2850°
2855°
2860°
2865°
2870°
2875°
2880°
2885°
2890°
2895°
2900°
2905°
2910°
2915°
2920°
2925°
2930°
2935°
2940°
2945°
2950°
2955°
2960°
2965°
2970°
2975°
2980°
2985°
2990°
2995°
3000°
3005°
3010°
3015°
3020°
3025°
3030°
3035°
3040°
3045°
3050°
3055°
3060°
3065°
3070°
3075°
3080°
3085°
3090°
3095°
3100°
3105°
3110°
3115°
3120°
3125°
3130°
3135°
3140°
3145°
3150°
3155°
3160°
3165°
3170°
3175°
3180°
3185°
3190°
3195°
3200°
3205°
3210°
3215°
3220°
3225°
3230°
3235°
3240°
3245°
3250°
3255°
3260°
3265°
3270°
3275°
3280°
3285°
3290°
3295°
3300°
3305°
3310°
3315°
3320°
3325°
3330°
3335°
3340°
3345°
3350°
3355°
3360°
3365°
3370°
3375°
3380°
3385°
3390°
3395°
3400°
3405°
3410°
3415°
3420°
3425°
3430°
3435°
3440°
3445°
3450°
3455°
3460°
3465°
3470°
3475°
3480°
3485°
3490°
3495°
3500°
3505°
3510°
3515°
3520°
3525°
3530°
3535°
3540°
3545°
3550°
3555°
3560°
3565°
3570°
3575°
3580°
3585°
3590°
3595°
3600°
3605°
3610°
3615°
3620°
3625°
3630°
3635°
3640°
3645°
3650°
3655°
3660°
3665°
3670°
3675°
3680°
3685°
3690°
3695°
3700°
3705°
3710°
3715°
3720°
3725°
3730°
3735°
3740°
3745°
3750°
3755°
3760°
3765°
3770°
3775°
3780°
3785°
3790°
3795°
3800°
3805°
3810°
3815°
3820°
3825°
3830°
3835°
3840°
3845°
3850°
3855°
3860°
3865°
3870°
3875°
3880°
3885°
3890°
3895°
3900°
3905°
3910°
3915°
3920°
3925°
3930°
3935°
3940°
3945°
3950°
3955°
3960°
3965°
3970°
3975°
3980°
3985°
3990°
3995°
4000°
4005°
4010°
4015°
4020°
4025°
4030°
4035°
4040°
4045°
4050°
4055°
4060°
4065°
4070°
4075°
4080°
4085°
4090°
4095°
4100°
4105°
4110°
4115°
4120°
4125°
4130°
4135°
4140°
4145°
4150°
4155°
4160°
4165°
4170°
4175°
4180°
4185°
4190°
4195°
4200°
4205°
4210°
4215°
4220°
4225°
4230°
4235°
4240°
4245°
4250°
4255°
4260°
4265°
4270°
4275°
4280°
4285°
4290°
4295°
4300°
4305°
4310°
4315°
4320°
4325°
4330°
4335°
4340°
4345°
4350°
4355°
4360°
4365°
4370°
4375°
4380°
4385°
4390°
4395°
4400°
4405°
4410°
4415°
4420°
4425°
4430°
4435°
4440°
4445°
4450°
4455°
4460°
4465°
4470°
4475°
4480°
4485°
4490°
4495°
4500°
4505°
4510°
4515°
4520°
4525°
4530°
4535°
4540°
4545°
4550°
4555°
4560°
4565°
4570°
4575°
4580°
4585°
4590°
4595°
4600°
4605°
4610°
4615°
4620°
4625°
4630°
4635°
4640°
4645°
4650°
4655°
4660°
4665°
4670°
4675°
4680°
4685°
4690°
4695°
4700°
4705°
4710°
4715°
4720°
4725°
4730°
4735°
4740°
4745°
4750°
4755°
4760°
4765°
4770°
4775°
4780°
4785°
4790°
4795°
4800°
4805°
4810°
4815°
4820°
4825°
4830°
4835°
4840°
4845°
4850°
4855°
4860°
4865°
4870°
4875°
4880°
4885°
4890°
4895°
4900°
4905°
4910°
4915°
4920°
4925°
4930°
4935°
4940°
4945°
4950°
4955°
4960°
4965°
4970°
4975°
4980°
4985°
4990°
4995°
5000°
5005°
5010°
5015°
5020°
5025°
5030°
5035°
5040°
5045°
5050°
5055°
5060°
5065°
5070°
5075°
5080°
5085°
5090°
5095°
5100°
5105°
5110°
5115°
5120°
5125°
5130°
5135°
5140°
5145°
5150°
5155°
5160°
5165°
5170°
5175°
5180°
5185°
5190°
5195°
5200°
5205°
5210°
5215°
5220°
5225°
5230°
5235°
5240°
5245°
5250°
5255°
5260°
5265°
5270°
5275°
5280°
5285°
5290°
5295°
5300°
5305°
5310°
5315°
5320°
5325°
5330°
5335°
5340°
5345°
5350°
5355°
5360°
5365°
5370°
5375°
5380°
5385°
5390°
5395°
5400°
5405°
5410°
5415°
5420°
5425°
5430°
5435°
5440°
5445°
5450°
5455°
5460°
5465°
5470°
5475°
5480°
5485°
5490°
5495°
5500°
5505°
5510°
5515°
5520°
5525°
5530°
5535°
5540°
5545°
5550°
5555°
5560°
5565°
5570°
5575°
5580°
5585°
5590°
5595°
5600°
5605°
5610°
5615°
5620°
5625°
5630°
5635°
5640°
5645°
5650°
5655°
5660°
5665°
5670°
5675°
5680°
5685°
5690°
5695°
5700°
5705°
5710°
5715°
5720°
5725°
5730°
5735°
5740°
5745°
5750°
5755°
5760°
5765°
5770°
5775°
5780°
5785°
5790°
5795°
5800°
5805°
5810°
5815°
5820°
5825°
5830°
5835°
5840°
5845°
5850°
5855°
5860°
5865°
5870°
5875°
5880°
5885°
5890°
5895°
5900°
5905°
5910°
5915°
5920°
5925°
5930°
5935°
5940°
5945°
5950°
5955°
5960°
5965°
5970°
5975°
5980°
5985°
5990°
5995°
6000°
6005°
6010°
6015°
6020°
6025°
6030°
6035°
6040°
6045°
6050°
6055°
6060°
6065°
6070°
6075°
6080°
6085°
6090°
6095°
6100°
6105°
6110°
6115°
6120°
6125°
6130°
6135°
6140°
6145°
6150°
6155°
6160°
6165°
6170°
6175°
6180°
6185°
6190°
6195°
6200°
6205°
6210°
6215°
6220°
6225°
6230°
6235°
6240°
6245°
6250°
6255°
6260°
6265°
6270°
6275°
6280°
6285°
6290°
6295°
6300°
6305°
6310°
6315°
6320°
6325°
6330°
6335°
6340°
6345°
6350°
6355°
6360°
6365°
6370°
6375°
6380°
6385°
6390°
6395°
6400°
6405°
6410°
6415°
6420°
6425°
6430°
6435°
6440°
6445°
6450°
6455°
6460°
6465°
6470°
6475°
6480°
6485°
6490°
6495°
6500°
6505°
6510°
6515°
6520°
6525°
6530°
6535°
6540°
6545°
6550°
6555°
6560°
6565°
6570°
6575°
6580°
6585°
6590°
6595°
6600°
6605°
6610°
6615°
6620°
6625°
6630°
6635°
6640°
6645°
6650°
6655°
6660°
6665°
6670°
6675°
6680°
6685°
6690°
6695°
6700°
6705°
6710°
6715°
6720°
6725°
6730°
6735°
6740°
6745°
6750°
6755°
6760°
6765°
6770°
6775°
6780°
6785°
6790°
6795°
6800°
6805°
6810°
6815°
6820°
6825°
6830°
6835°
6840°
6845°
6850°
6855°
6860°
6865°
6870°
6875°
6880°
6885°
6890°
6895°
6900°
6905°
6910°
6915°
6920°
6925°
6930°
6935°
6940°
6945°
6950°
6955°
6960°
6965°
6970°
6975°
6980°
6985°
6990°
6995°
7000°
7005°
7010°
7015°
7020°
7025°
7030°
7035°
7040°
7045°
7050°
7055°
7060°
7065°
7070°
7075°
7080°
7085°
7090°
7095°
7100°
7105°
7110°
7115°
7120°
7125°
7130°
7135°
7140°
7145°
7150°
7155°
7160°
7165°
7170°
7175°
7180°
7185°
7190°
7195°
7200°
7205°
7210°
7215°
7220°
7225°
7230°
7235°
7240°
7245°
7250°
7255°
7260°
7265°
7270°
7275°
7280°
7285°
7290°
7295°
7300°
7305°
7310°
7315°
7320°
7325°
7330°
7335°
7340°
7345°
7350°
7355°
7360°
7365°
7370°
7375°
7380°
7385°
7390°
7395°
7400°
7405°
7410°
7415°
7420°
7425°
7430°
7435°
7440°
7445°
7450°
7455°
7460°
7465°
7470°
7475°
7480°
7485°
7490°
7495°
7500°
7505°
7510°
7515°
7520°
7525°
7530°
7535°
7540°
7545°
7550°
7555°
7560°
7565°
7570°
7575°
7580°
7585°
7590°
7595°
7600°
7605°
7610°
7615°
7620°
7625°
7630°
7635°
7640°
7645°
7650°
7655°
7660°
7665°
7670°
7675°
7680°
7685°
7690°
7695°
7700°
7705°
7710°
7715°
7720°
7725°
7730°
7735°
7740°
7745°
7750°
7755°
7760°
7765°
7770°
7775°
7780°
7785°
7790°
7795°
7800°
7805°
7810°
7815°
7820°
7825°
7830°
7835°
7840°
7845°
7850°
7855°
7860°
7865°
7870°
7875°
7880°
7885°
7890°
7895°
7900°
7905°
7910°
7915°
7920°
7925°
7930°
7935°
7940°
7945°
7950°
7955°
7960°
7965°
7970°
7975°
7980°
7985°
7990°
7995°
8000°
8005°
8010°
8015°
8020°
8025°
8030°
8035°
8040°
8045°
8050°
8055°
8060°
8065°
8070°
8075°
8080°
8085°
8090°
8095°
8100°
8105°
8110°
8115°
8120°
8125°
8130°
8135°
8140°
8145°
8150°
8155°
8160°
8165°
8170°
8175°
8180°
8185°
8190°
8195°
8200°
8205°
8210°
8215°
8220°
8225°
8230°
8235°
8240°
8245°
8250°
8255°
8260°
8265°
8270°
8275°
8280°
8285°
8290°
8295°
8300°
8305°
8310°
8315°
8320°
8325°
8330°
8335°
8340°
8345°
8350°
8355°
8360°
8365°
8370°
8375°
8380°
8385°
8390°
8395°
8400°
8405°
8410°
8415°
8420°
8425°
8430°
8435°
8440°
8445°
8450°
8455°
8460°
8465°
8470°
8475°
8480°
8485°
8490°
8495°
8500°
8505°
8510°
8515°
8520°
8525°
8530°
8535°
8540°
8545°
8550°
8555°
8560°
8565°
8570°
8575°
8580°
8585°
8590°
8595°
8600°
8605°
8610°
8615°
8620°
8625°
8630°
8635°
8640°
8645°
8650°
8655°
8660°
8665°
8670°
8675°
8680°
8685°
8690°
8695°
8700°
8705°
8710°
8715°
8720°
8725°
8730°
8735°
8740°
8745°
8750°
8755°
8760°
8765°
8770°
8775°
8780°
8785°
8790°
8795°
8800°
8805°
8810°
8815°
8820°
8825°
8830°
8835°
8840°
8845°
8850°
8855°
8860°
8865°
8870°
8875°
8880°
8885°
8890°
8895°
8900°
8905°
8910°
8915°
8920°
8925°
8930°
8935°
8940°
8945°
8950°
8955°
8960°
8965°
8970°
8975°
8980°
8985°
8990°
8995°
9000°
9005°
9010°
9015°
9020°
9025°
9030°
9035°
9040°
9045°
9050°
9055°
9060°
9065°
9070°
9075°
9080°
9085°
9090°
9095°
9100°
9105°
9110°
9115°
9120°
9125°
9130°
9135°
9140°
9145°
9150°
9155°
9160°
9165°
9170°
9175°
9180°
9185°
9190°
9195°
9200°
9205°
9210°
9215°
9220°
9225°
9230°
9235°
9240°
9245°
9250°
9255°
9260°
9265°
9270°
9275°
9280°
9285°
9290°
9295°
9300°
9305°
9310°
9315°
9320°
9325°
9330°
9335°
9340°
9345°
9350°
9355°
9360°
9365°
9370°
9375°
9380°
9385°
9390°
9395°
9400°
9405°
9410°
9415°
9420°
9425°
9430°
9435°
9440°
9445°
9450°
9455°
9460°
9465°
9470°
9475°
9480°
9485°
9490°
9495°
9500°
9505°
9510°
9515°
9520°
9525°
9530°
9535°
9540°
9545°
9550°
9555°
9560°
9565°
9570°
9575°
9580°
9585°
9590°
9595°
9600°
9605°
9610°
9615°
9620°
9625°
9630°
9635°
9640°
9645°
9650°
9655°
9660°
9665°
9670°
9675°
9680°
9685°
9690°
9695°
9700°
9705°
9710°
9715°
9720°
9725°
9730°
9735°
9740°
9745°
9750°
9755°
9760°
9765°
9770°
9775°
9780°
9785°
9790°
9795°
9800°
9805°
9810°
9815°
9820°
9825°
9830°
9835°
9840°
9845°
9850°
9855°
9860°
9865°
9870°
9875°
9880°
9885°
9890°
9895°
9900°
9905°
9910°
9915°
9920°
9925°
9930°
9935°
9940°
9945°
9950°
9955°
9960°
9965°
9970°
9975°
9980°
9985°
9990°
9995°
10000°


WORLD PETROLEUM
APRIL 1942
Oil Map
OF THE
NEAR AND MIDDLE EAST
SCALE
Miles
Kilometers
RUSSIAN TURKISTAN
CHINESE TURKISTAN
TIBET
AFGHANISTAN
IRAN (PERSIA)
INDIA
BALUCHISTAN
DHOFAR
Aral Sea
Arabian Sea
Bay of Bengal
Himalaya Mountains
Indo Burma Petroleum Co.,Ltd. holds 18,833 acres of scattered prospecting licenses in North West Frontier Province in Bannu (A) Dera Ismail Khan (B) and Kohat (C) districts
Attock Oil Co.,Ltd. holds 150 acres in Dera Ismail Khan (B)
Burmah Oil Co.,Ltd. holds 2,995 acres in Dera Ismail Khan (B) and 2,535 acres in Attock (D) district of Punjab
ATTOCK OIL CO. LTD CONCESSION
ANGLO-IRANIAN OIL CO. LTD. CONCESSION
N.V. ALGEMEENE EXPLORATIE MIJ OIL CONCESSION
PETROLEUM DEVELOPMENT (OMAN & DHOFAR) LTD. CONCESSION
Legend
PROVEN OIL FIELD
REFINERY
TANKER TERMINAL
PIPELINE
SUPPLY ROUTES
RAILROAD
INTERNATIONAL BOUNDARY

were, however, concentrated on other sea lanes—a mistake which certainly would not be repeated. Since the outbreak of war many German high command reports have mentioned specifically that tankers have been singled out for Nazi attack while press notices have announced an impending shortage of oil in Allied countries—interesting indications of German aspirations and hopes.

As far as the Far Eastern area is concerned, it was, of course, well known to the Allies that it would be difficult to defend in case of war with Japan, and it is not surprising that practically all of it has been lost in less than three months. This conquest by Japan represents the successful execution of a long cherished, well prepared plan, on which the whole future of Nipponese war economy was staked. What its loss means to the supplies of Allied territories in that part of the world will be discussed later on.

But the second area, the Near and Middle East, cannot also be qualified as a completely safe Allied possession. Here it is Germany that must be watched. Nazi intentions in regard to the oil of the Near and Middle East are well known, and expansion towards these regions is an old German dream unsuccessfully attempted in the war of 1914-18. The Libyan campaign with its changing fortunes, and the struggle in Southern Russia may be regarded as preliminaries to a final show-down. Aside from the effect which control of these areas might have on the oil situation of the Axis, it is worth considering the bearing which such an attempt, successful or not, may have on Allied oil supplies. It is to be hoped that Allied strategy in this area will not confine itself to emergency measures after the event, but will be directed to anticipating and forestalling the plans of the enemy. Even if the Axis fails to conquer these territories they may very well become a battle zone, and the oilfields and refining installations may have to be destroyed as a precautionary measure, transport may become impossible or other events may occur which would temporarily deprive the Allies of their use. It is worthy of note that the Nazis may first try to conquer or interrupt operations only in one or two of the oil producing countries of the Near and Middle East; but they will scarcely be able to utilize these conquests fully without assuring sea communications from the oilfields to Italy or Southern Europe. In the case of the Caucasus, this would mean control of the Black Sea, the Dardanelles, and the Eastern Mediterranean, while in the case of Persia they would have to be able to ship their oil via the Suez Canal and the Mediterranean. It is thus more than likely that the Nazis, once successful, will spread their attacks over a large part of the Near and Middle East including all the important oilfields.

Near and Middle East oilfields are the most suitable bases of supply for Allied possessions in Asia, Oceania, and East and South Africa. Of the producers in that part of the world, Iraq sent the bulk of its oil to European countries before the war, mainly to France, and a smaller part to England, Italy and Spain. Shortly after the outbreak of hostilities, however, the new refinery at Haifa started operations so that the Eastern Mediterranean area drew from then onwards a proportion of its oil from Iraq. Until 1939 Persia shipped over 50 percent of its export to England, Germany and other European countries. With the beginning of the war, and especially after the entry of Italy into the fight, transport via the Suez Canal and through the Mediterranean became too dangerous, and the way around the Cape of Good Hope was too long to be practicable with the restricted transport capacity at hand. A reduction in output thus became necessary in the case of Persia, as well as that of other producers, but as no official statistics are now published, exact data are not available. The only relevant point is that up to now as much oil as required was available in a geographical and strategically favorable position for the bases in Asia, Africa and Oceania. Its importance for Allied naval and merchant operations in these seas and for military requirements for the campaign in Libya and for the building up of an army in the Near and Middle East can scarcely be exaggerated. The fact that Britain occupied Iraq, Syria and Persia (the latter in collaboration with Russia), during the second half of 1941 is proof enough of the Allied determination to maintain control over these territories. This Allied occupation put the oil production, which was mainly owned by British, Dutch and American companies, in these countries under Allied supervision. All the necessary measures for defense against an Axis invasion could then be taken. The final conquest of Eritrea and Abyssinia served to protect the flank of this vital region and to deprive the Axis of bases from which it might have been possible to launch at-

TABLE I*

Quantities in Thousands of Barrels

AREA I Western Hemisphere		AREA II Near and Middle East		AREA III Far East		AREA IV Axis	
Country	Crude Oil Production	Country	Crude Oil Production	Country	Crude Oil Production	Country	Crude Oil Production
U.S.A.	1,405,830	Russian Caucasian area	201,000	Dutch East Indies.	62,130	Rumania	40,563
Venezuela	222,962	Persia	78,035	Burma	7,762	Germany, Austria and Czechoslovakia	5,239
Mexico	41,200	Bahrein and Saudi Arabia	12,716	British Borneo	6,864	Japan proper	2,659
Colombia	24,442	Iraq (a)	12,650	Sakhalin	3,300	Italy and Albania	1,427
Other Countries	67,382	Egypt	7,659	British India	2,270	Other Countries	6,271
Total 1941	1,761,756	Total 1941	312,060	Total 1941	82,326	Total 1941	56,159
Total Operating refining capacity (c)	1,990,000	Total Operating refining capacity (c)	360,000	Total Operating refining capacity (b) (c)	83,000	Total Operating refining capacity (c)	210,000

* Crude oil production figures taken from World Petroleum. Estimated in the case of some countries.
(a) 1939 production 30,791,000 bbl.
(b) Including Australia.
(c) Partly estimated.

TABLE II

Quantities in Thousands of Barrels

Territories	Total Imports 1939	Persia	Bahrein	Dutch East Indies, British Borneo (a)	Burma	Western Hemisphere
Allied Countries						
Australia (b)	17,869	2,155	1,429	11,544	28	2,362
British India	13,514	4,179	956	1,025	5,009	432
Union of South Africa	10,656	5,281	1,076	2,735	67	1,370
New Zealand	5,117	75	506	3,741	—	670
Aden	4,563	3,900	201	419	—	—
China (c)	4,032	—	—	2,565	11	1,037
Ceylon	3,306 (d)	1,113	610	1,493	—	21
Southern Rhodesia	467	123	15	191	8	84
Total Allied Countries	59,524	16,826	4,793	23,713	5,123	5,976
Japanese Controlled						
British Malaya	10,857 (e)	320	—	9,928	—	243
Philippines	3,909 (f)	—	—	1,530	—	2,377
Hongkong	2,062 (g)	—	—	1,313	—	730
French Indo-China (h)	899	—	—	767	—	124
Siam (Thailand)	532 (i)	—	—	364	—	117
Total Japanese Controlled (k)	18,259	320	—	13,842	—	3,591

(a) Including exports via British Malaya and Straits Settlements.
(b) Year ending June 30, 1939.
(c) Official trade statistics include only partial imports of occupied China and do not show all shipments to Free China.
(d) Re-exports 2,253,000 bbls., mostly for bunkers.
(e) 1938 statistics, re-exports 5,545,000 barrels.
(f) 1940 imports increased to 6,205,000 barrels.
(g) Re-exports 717,000 barrels.
(h) 1938 statistics.
(i) 1940 imports increased to 1,361,000 barrels mostly from U. S.
(k) In 1939 Japan proper imported some 28 million bbls. from the United States and appreciable further quantities from the Middle and Far East producers.

Left, Javanese buffalo drawing a rubber tired tank cart in Western Java before this important Allied oil supply source was lost; photo from Triangle. Above, loading Black Sea tankers in the Russian port of Batum; the Russian oil supply situation is rapidly improving as a result of the decrease in demand by some 12 million tons annually due to the loss of the Ukraine; photo by Sovfoto.

tacks on the transport routes and oil targets of the East. German attempts to conquer Caucasian oil areas before winter set in were finally frustrated by the unexpected Russian resistance.

Thus far it has been possible to keep the Near and Middle Eastern area and its strategic approaches under Allied control. Even the fact that oil from this area has been shut off almost completely from the United Kingdom since the early stages of the war is without great strategic importance for the Western Hemisphere is as convenient a source as Persia or Iraq. Germany it is true had banked on the fact that Britain, compelled to buy her oil in America, would not possess sufficient foreign resources to acquire petroleum stocks; but Lease-Lend shattered these expectations. In the meantime Allied countries outside Europe and the Western Hemisphere have continued to obtain most of their oil from the Near and Middle East, with the exception of Oceania, which depended largely on the Dutch East Indies, now lost, and India, which received a large part of her requirements from Burma.

The main non-European markets for Near, Middle, and Far Eastern oil are shown in the accompanying table, which gives the imports according to origin for 1939, the last year for which trade statistics are available. Japan will not benefit immediately from its Eastern oil conquests but may be able to replace the 20,000,000 to 30,000,000 bbl. previously imported annually from the Western Hemisphere at some indefinite date in the future, if allowed an opportunity to restore the East Indian fields and provide sufficient transport capacity. The position of the Far Eastern countries still in Allied possession is perhaps more difficult. They imported in 1939 a total of 59,525,000 bbl. of which 21,619,000 bbl. came from the Near and Middle East, 28,836,000 bbl. from the Far East, and 5,976,000 bbl. from the Western Hemisphere. While sufficient oil is available in the Americas to replace the imports from the Far East, and if need be those from the Near and Middle East, the loss of refining capacity, especially for aviation gasoline in Netherlands India is a serious blow and difficulties may arise in replacing the output of other products, as for instance that of Persian fuel oil. More serious would be the increased demand on tanker capacity if Oceania, India or Africa should have to depend completely on supplies from the East or West Coast of America, and if armies and navies in those areas had to depend on these same supplies. It would not be an easy task to maintain sea communications without proper bases and in waters infested by enemy raiders. The distance from the United States West Coast to Australia is 6,966 miles, compared with 3,800 miles from the Dutch East Indies, or 7,550 miles from Persia. It is worth mentioning that even last year the strained tanker position compelled Australia to import more oil from the Dutch East Indies, and less from Persia.

It is this question of transport capacity and maintaining communications on which the oil problem, as practically all other supply problems, hinges. It is on interruption of communication that Germany bases her hopes for piecemeal invasion and conquest. Actually Axis attacks on tankers now must be looked upon as part and parcel of a comprehensive plan to dislocate Allied supply lines and even as preparation for land attacks on the oil centers of the Near and Middle East. Only if the Allies should be unable to replace the oil shipments from these countries could the Axis hope to benefit to the fullest extent from an eventual conquest of these territories. The Axis undoubtedly has learned a lesson from blunders it committed in the first phase of the war. At that time they might have been able to prevent so large a proportion of the then neutral tanker fleet from passing into the service of the British. In the meantime, they have learned that the clue to the Allied oil position is the question of sufficient transport capacity and maintenance of sea communications and they are fully aware of the effect which a conquest of Allied supply bases must ultimately have on the shipping position.

To prevent the United Nations' petroleum outlook from suffering critical deterioration it is evident that the oilfields of the Near and Middle East and of the Caucasus must be held at all costs. It would not be sufficient to destroy these fields, merely depriving the Axis of immediate use of this oil; continuous supply of petroleum products from the refineries at Abadan, Haifa

British Indian troops arrive at the Abadan refinery in Persia to insure the prevention of sabotage. Not only would the oil of the Middle East give the Nazis a tremendous advantage, but would require that all Allied supplies be shipped from North and South America, greatly prolonging the war; photo by British Combine.

and Bahrein is almost as essential to the Allies as it would be to the Axis. Their problem is thus to make good the actual loss of the Far East fields and to prepare for any emergency which might or might not arise in the Near and Middle East.

The country in the most difficult position is probably China. Less than 10,000 bbl. of gasoline a year are produced locally. After the loss of Rangoon the only remaining important line of supply is the North West Road, originating at Sergiobal on the branch of the trans-Siberian Railway and running some 2,000 miles through Sinkiang, Kansu and Shansi to Chungking. A new highway from India's Assam province to Sikang is still under construction. Every drop of oil that can be spared in Russia or India and for which transport can be found presumably will be dispatched over these routes. The United Nations in the meantime can send oil to those two countries from which China may still be supplied. From a military viewpoint the vital importance to the United Nations of protecting the oil of the Caucasus and the Near East is evident from a glance at the map. Naval and land operations to reclaim the territory already lost and to attain final victory over the Axis powers must extend over a vast area and be maintained for an indefinite period of time. It will be far easier to fuel Allied ships from the Persian Gulf or the oil ports of the Eastern Mediterranean than from across two broad oceans. There is a great and obvious advantage in producing as much as possible of the aviation gasoline and other products required by planes and ships at Near East refineries instead of attempting to bring all of these essential war materials from the opposite side of the globe. Aside from the hazards of these long ocean voyages it is questionable whether transport capacity exists or can be provided quickly enough to sustain a prolonged offensive on the scale that obviously will be required.

In addition to protecting the all-important oil resources of the Near East which they still hold and in addition to moving supplies to Brtiain, Russia and China in support of their war effort, large stocks need to be built up in selected and well protected parts of Asia, Africa, and Oceania to compensate as well as possible for actual and threatened loss of supply sources and transport connections. Australia, New Zealand and South Africa received in 1939 over 18,000,000 bbl. from the now lost Dutch East Indies and British Borneo, while India's imports of over 5,000,000 bbl. from Burma are also interrupted by now. Another 15,700,000 bbl. went to these four countries from the Near and Middle East, while the Western Hemisphere participated in their supply with only 4,800,000 bbl. Domestic production of shale oil, motor alcohol and benzol in Australia is less than 500,000 bbl., or three percent of total imports, while India proper had an output of 2,270,000 bbl. in 1941. South Africa possesses some torbanite deposits though developed only on a small scale, while New Zealand is bare of any oil resources. The building up of large stocks in all of these countries is a precaution that cannot be neglected.

Allied resources should be still adequate to fulfill such a task if non-essential requirements were curtailed everywhere. This curtailment as mentioned already and as shown by figures in an accompanying table, is not necessary on account of lack of producing capacity. It is necessary in order to release sufficient tanker space for the transport of oil to the countries and bases indicated. The reason for rationing in America is thus not the development of stocks on the Atlantic Coast or the Western Pacific area, but the level of reserves available in all the various United Nations. That the United States is aware of its responsibility toward the common cause is shown by the fact that rationing methods already have been instituted on the advice of the oil industry itself. Such a measure of strategic distribution of sufficient oil supplies over the various Allied nations should further be accompanied by an absolute cessation of all unessential uses of petroleum products in every country to which oil must be brought over perilous transport routes. The United States has a duty and a right to insist on such an economy. It is perhaps worth mentioning that since the outbreak of war in the countries of the British Empire and in Britain itself certain, though reduced quantities of motor fuel were given to all license holders for private cars in the form of basic rations. The British government has announced that after July 1942 no motor fuel will be made available for pleasure purposes; but there and elsewhere more may still be done. The use of tar oil, benzol and other substitutes could be increased and other efforts made to reduce import demands for oil as much as possible and to restrict its use to essential industrial and military requirements. A lesson can be learned from the Axis countries where private motor cars, taxis, and other oil powered vehicles have disappeared and unnecessary uses have been eliminated. Fortunately, measures in Allied countries need not be so severe and need not include restriction upon really essential uses or resort to inferior qualities of petroleum products.

Allied strategy to counter Axis efforts to disrupt the oil supplies of the United Nations is just emerging from a period of transition. In the first phase of the war, too much dependence was placed on an anticipated oil shortage in the Axis countries, while at the same time insufficient efforts were made to destroy their source of supply. Attacks on Axis oil sources will still form a part of the Allied campaign since they will be directed at one of the greatest weaknesses in Germany's and Italy's economic armament. But in this study we have been less concerned with this phase of economic warfare than with the necessary counter measures against Axis attacks on Allied oil supplies.

Successful defense of the oil producing possessions of the United Nations is of first importance. Plans for the destruction of facilities in areas that cannot be defended have their place. But the purely negative measure of depriving the Axis of the potential benefits of its conquests is no longer sufficient. The United Nations must provide the replacement of lost raw material resources over increasingly dangerous and lengthening routes. In order to avoid possible shortages it is essential to accumulate large stocks at all strategic points within the theatre of future military operations. Other Allied countries can help by developing domestic resources wherever possible and restricting consumption to absolutely essentials. In the Western Hemisphere the oil industry is devoting its full energies to supplying the sinews of war for national and Allied needs and Americans are prepared to undergo whatever restriction this program may involve, recognizing that the primary necessity is to maintain the supply of oil at all points it is needed for the utmost prosecution of the war.

KESSLER Describes Scorched Earth Results In East Indies

By Henry van Dam

Netherlands East Indies
News Agency

Voluntary Destruction of Oil Installations Valued at $500,000,000 Before Japanese Occupation of the East Indies Constitutes a Serious Blow to the Enemy—Extent and Possibility of Rehabilitation Reviewed by Managing Director of Royal Dutch.

Above, cracking units of a Royal Dutch Shell refinery in the Netherlands Indies destroyed by the Dutch military authorities in cooperation with engineers of the company before Japanese occupation of this important producing and refining center. Left, J. B. Aug. Kessler, Joint Managing Director of the Royal Dutch Shell Group.

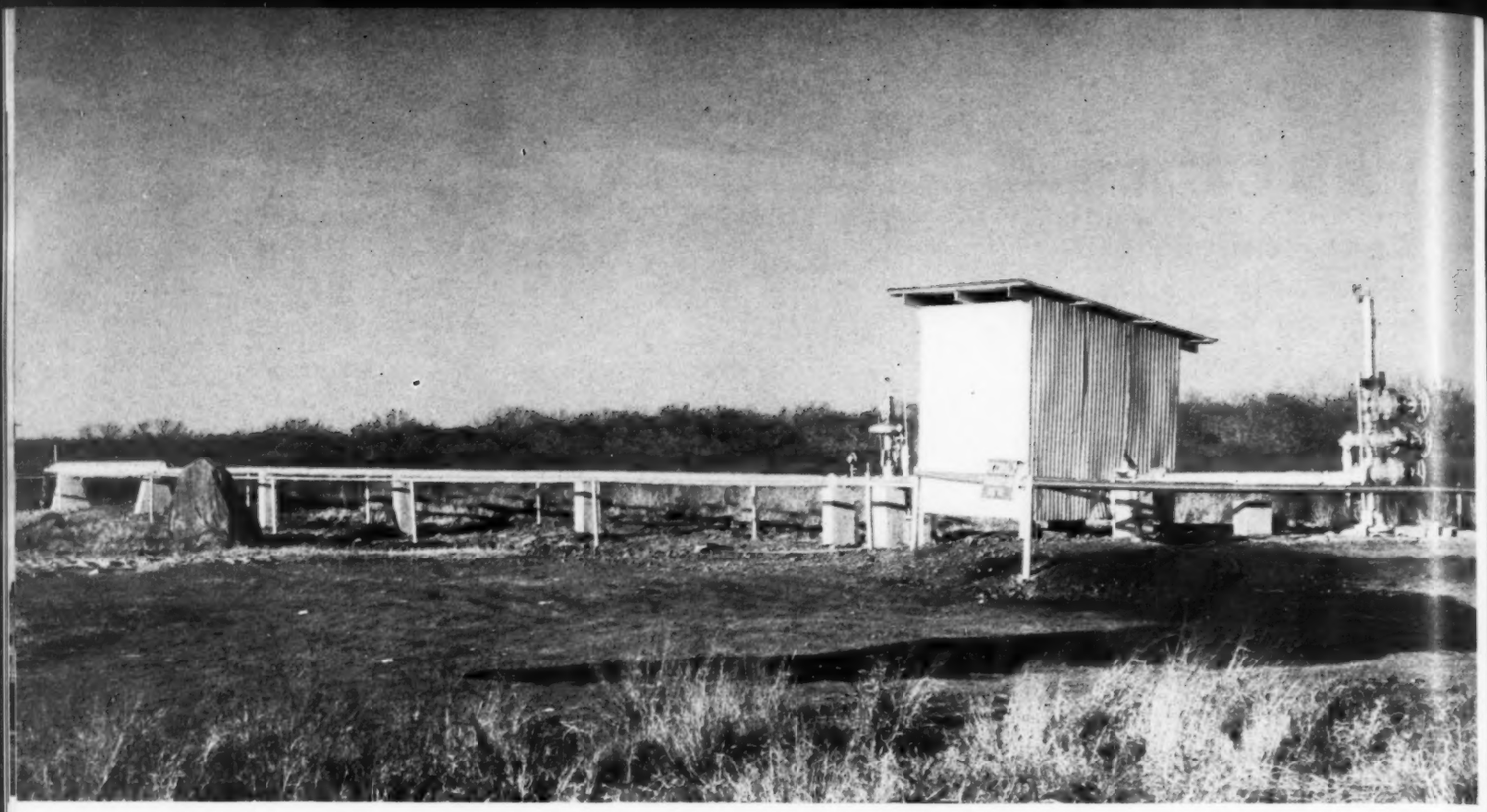
J. B. Aug. Kessler, Joint Managing Director of the Royal Dutch Shell Group recently described to a limited extent the destruction of oil installations in Netherlands India. While full details were not available due to military restrictions, Mr. Kessler did answer as far as possible questions as to the extent of the damage and the possibility of rehabilitating the fields during Japanese occupation and subsequently when the Dutch again gain control. Mr. Kessler gave his views of these important matters in an interview granted in London to Henry van Dam of the Netherlands Indies News Agency. The Royal Dutch group is by far the largest operator in the East Indies.

"I must make it very clear," said Mr. Kessler at the beginning of the interview, "that whatever the Dutch have done to prevent the Japanese getting the oil has been part of a deliberate offensive against the enemy. We do not compute it in terms of financial sacrifice, nor do we pat ourselves on the back as being either heroes or martyrs. It is just one of the ways in which we are trying to help win the war. But we do feel entitled to look upon the scorched earth policy at Tarakan, Balik Papan and Palembang as something great. Had these wells been under enemy control and had we sent our bombers to blow them up, we should have acclaimed even a fraction of the present destruction as a mighty achievement — a vital blow struck against the Axis, a spectacular triumph of war. So, to have wiped them out so conclusively, and so much more thoroughly before they fell into enemy hands, is surely as important as a victory."

Asked about the extent of the destruction, Kessler said: "The very detailed plans we had made appear to have been carried out with remarkable thoroughness. The destruction of oil installations is, of course a most complicated business. Only technicians thoroughly acquainted with the production of oil could do it. This work was carried out by the military authorities. But many of our men at these centers had joined up as auxiliaries under the mobilization scheme, and helped the military in carrying out the work of destroying the centers. To give you an idea of its thoroughness I might point out that whole settlements, indeed almost the whole of the towns themselves, were destroyed. Everything went. Not only the wells and the machinery, but the oil-tin factories, the printing works, the stores, the shops, the clubs, and even the dwelling houses. These Dutch families, who had made the most delightful homes in the outposts, sacrificed everything as their share of the offensive against Japan. It is one thing, you know, for us in Britain to stand up uncomplainingly to our homes being demolished by German bombers. But how much greater determination does it need to take a personal part in the deliberate cold-blooded destruction of all that you have in the world.

"An oil installation is no easy thing to blow up. The wells may be scattered over an enormous area. Some fields consist of a great number of wells yielding only a few tons each day. Indeed, the thousand or so Tarkan and Balik Papan wells averaged only about five tons a day each, even though the actual output of those two fields was

(Continued on page 45)



One of the gas input wells of the pressure maintenance project of the Plymouth Oil Company in Texas.

War Economy Served By PRESSURE MAINTENANCE

By H. M. Livezey

Chief Petroleum Engineer
Plymouth Oil Company

Sixty Percent Increase in Recovery With a Fraction of the Material Required for Drilling that Number of Additional Wells.

RETURN to the producing horizon of gas produced with oil during initial production has not been generally acknowledged by petroleum engineers and operators as being a profitable operation. Their failure to adopt pressure maintenance as a progressive method of producing oil may be due to the limited amount of history and experience on fields in which pressure maintenance programs have been operating, particularly in fields where the formation pressure is greater than 2,000 lbs. per sq. in.

For several years the optimum production rate of fields has been greater than the demand. The rate of production of oil has been regulated by law in nearly all the oil producing states. As new fields were discovered it has been necessary to reduce production from previously discovered fields. The primary purpose of the laws has been to conserve the natural resources and prevent physical waste, either in the formation or in storage. The benefits of conservation control are generally known and the operators are cooperating to conserve the natural resources. The operators can still further prevent physical waste and at the same time increase their ultimate production with a lower per barrel production cost by the installation of pressure maintenance systems in fields which now are thought to have an active water drive. At the present time there is another reason besides the ultimate recovery for considering the installation of pressure maintenance systems. The United Nations in this second world war need oil in greater amount than we have been producing. This additional oil will have to be produced with less material than ordinarily is used. This means that a large percentage of the oil must be secured from wells already drilled and not from the drilling of additional wells in proven fields. A study of production methods of the Plymouth Oil Company in the development of the Heep sand in the Plymouth Field, San Patricio County, Texas shows the economy and advantages derived from the installation and operation of a pressure maintenance system.

The Heep sand is a local designation of a sand in the Middle Frio Zone. In the Plymouth Field it is a blanket sand with a lensing out on the western edge and a slight dipping on the eastern edge. The sand has a gas cap present over the entire producing zone and is of sufficient thickness so that an oil-water contact is present over the entire field. This sand is at an average depth of 5,650 ft., has an average porosity of 34 percent and a permeability of 750 to 1,000 millidarcies. The first well was drilled in June, 1936. Drilling proceeded rapidly until in October, 1937 approximately 100 wells had been completed in this sand. The method of completion in practically all wells consisted of cementing the production casing to the total depth drilled and gun-perforating from three to five feet midway between the gas-oil contact and oil-water levels as determined for the individual wells.

Initial well allowables were high and in a relatively short period of time some of the wells started producing water. The assumption, which was natural at that time, was that an active water drive was present. A bottom hole pressure survey of the field was made in 1937. The results of this survey showed that instead of having an active water drive the pressures in the

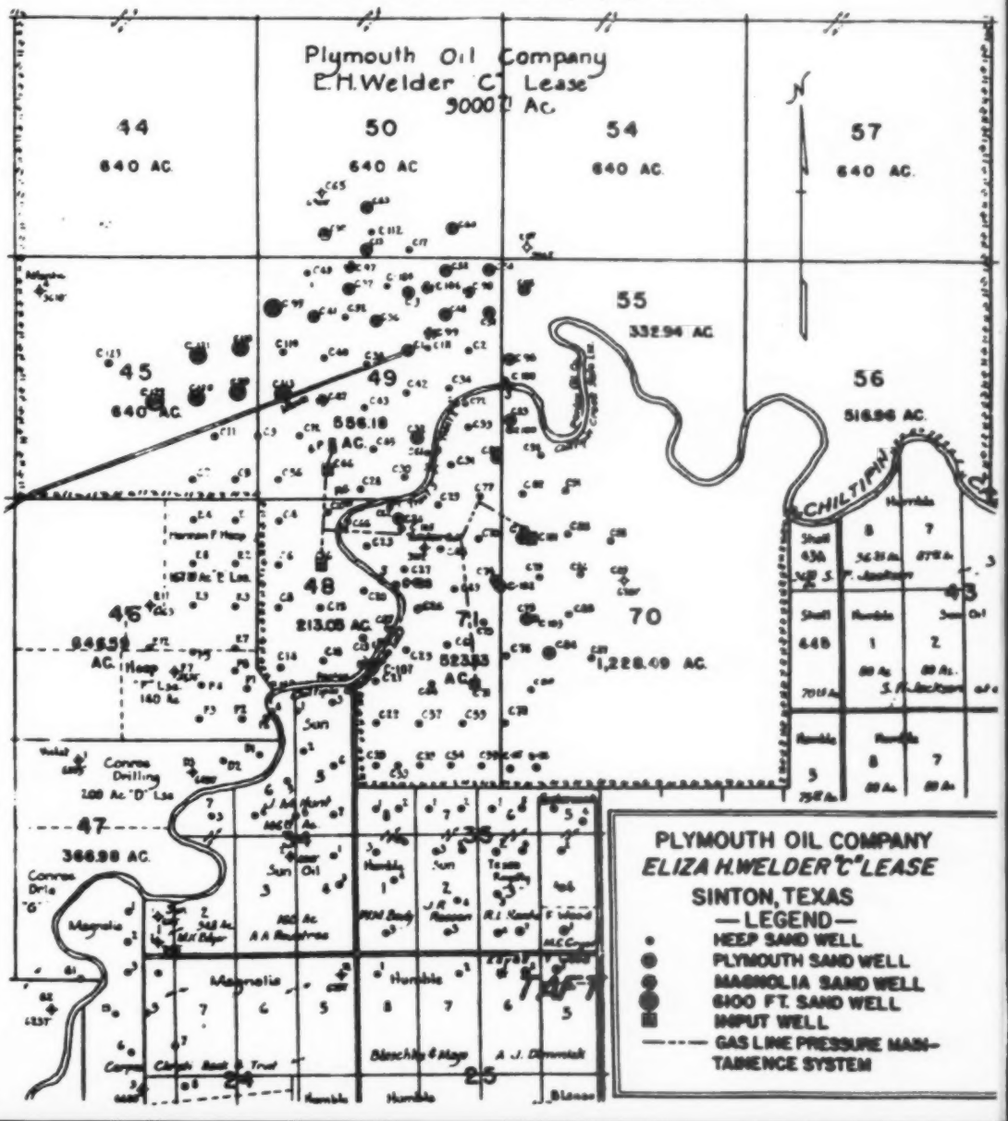
oil saturated section had been reduced and that the water production was caused by "coning". A thorough study of the field was then made to determine the amount, if any, of water drive present. This study showed some rise in the oil-water contact although not equal to the withdrawals. Tests also showed there was a rate of production at which the gas-oil ratio was practically the amount of gas which was in solution in the oil, and that if the rate of production was decreased the gas-oil ratios increased. About the time the study was completed the Railroad Commission reduced production rates. The conclusions of the study were that in order to obtain maximum recovery it would be necessary to inject the produced gas. Tests had shown that when production was at the rates prescribed by the Railroad Commission, gas production in excess of that in solution resulted, causing a loss of reservoir energy, and bringing about a corresponding loss of recoverable oil. Gas injection was started in December, 1939 and since that time we have been injecting approximately the amount of gas which is produced with the oil. Prior to gas injection into the sand, the average bottom hole pressure was declining at approximately four pounds per 100,000 bbl. of oil produced. After gas injection was started, this rate of decline decreased. Further gas injection not only gradually stopped the decline in bottom hole pressures, but caused an increase, and at the present time the pressures are 20 lbs. higher than at the time gas injection was started.

The gas is injected in four wells whose location is shown on the accompanying map of the field. Gasoline is first stripped from the produced gas by the Manhattan Gasoline Company and the residue gas is compressed by them from 33 lbs. gauge to 2350 lbs. gauge. Delivery of the gas is made to Plymouth at the compressor station and is transmitted to the injection wells through a three inch main line and two inch lateral lines. Each well is equipped with regulator, meter, check valve, and choke. It was thought that freezing would be prevented by the combination of the regulator and the choke. This method was satisfactory for a period of time until freezing in the main lines occurred. Investigation showed that this freezing was caused by an accumulation of lubricating oil in a foamy state together with condensed water vapor. A special scrubber was then placed at the end of the three inch line which removed all lubricating oil. Smaller drips were placed in expansion loops to remove condensed water vapors. Sufficient temperature did not remain in the gas to prevent freezing on the wells farthest removed from the gasoline plant and heaters were placed on the line to heat the gas before injection into these wells. The amount of gas injected in each well is determined by bottom hole pressure surveys which are made on all wells in the field. By these surveys, together with an accurate record of the production and gas-oil ratios of all wells in the field, it is possible to maintain constant pressures over the field and prevent the gas from channeling. The cost of returning the residue gas to the formation has been a negligible amount per barrel production.

The results which have been obtained from the operation of the pressure maintenance system are: (1) Dissolved gas has been held in solution. Analysis of oil sampled at formation pressures shows that if the pressures had continued to decline at the previous rate, approximately 15 percent of the dissolved gas would have been liberated. The liberation of dissolved gas is not only a loss of energy but causes an increase in the viscosity of the oil. As the viscosity of the oil is increased, additional energy is required to move the oil. The released gas further restricts the flow of oil. Therefore, by maintaining a constant formation pressure, we have conserved the energy of the dissolved gas and prevented the viscosity of the oil from increasing. (2) Edge water encroachment has been controlled and additional coning of water in the center of the field has been prevented. (3) Water production in the area in which the water had been "coned in" during the early life of the field has been reduced. (4) The net cost of production is less than it would have been without pressure maintenance because the cost of compressing and injecting the gas is less than the amount which it would have been necessary to spend in working over wells during this period. (5) The recoverable oil reserves now are probably 60 percent more than they would have been without pressure maintenance. (6) By returning the gas to the producing sand during the period when the production rate has been low, we have replaced the energy that would have been wasted by the higher gas-oil ratios. The field now has the same capacity for production it had when discovered. The production rate can be increased without causing physical waste.

The results which Plymouth Oil Company has obtained from the operation of a pressure maintenance system show that the amount of recoverable oil in a field can be increased as much as 60 percent by returning the gas to the sand, and that the daily rate of production can be increased without physical waste. Therefore, the industry's problem of producing more oil with less material apparently can be solved by the installation of pressure maintenance systems. The amount of materials necessary for these systems would be but a fraction of the amount necessary to drill and equip new wells in order to produce an amount of oil equal to the amount of additional production that can be secured from the present wells by the installation of pressure maintenance systems.

Map showing distribution of producing wells and input wells in the pressure maintenance undertaking described in the accompanying article.



Theoretical And Economic Significance Of GEODYNAMIC PROSPECTING

By Sylvain J. Pirson

THE PETROLEUM INDUSTRY is perhaps faced with the greatest exploration campaign in its history as the demand for petroleum products is constantly reaching higher levels whereas the rate of discovery of new oil fields is temporarily on the decline. The history of the industry has shown that the best and fastest way to meet the increased demand for crude oil is by an active wildcatting campaign created by the incentive of higher prices for crude. The ability of the industry to meet the challenge of greater demand for crude oil is largely dependent on its ability to increase the discovery rate of oil pools as it is true to state that the oil industry does not live out of its reserves but out of its discoveries. Presently, with the price of crude being pegged at a level where operating expenses are exceeded, on the average, by only a meager profit, with material and equipment becoming increasingly difficult to obtain, with the known discovery methods rapidly reaching their point of minimum return, the industry has lacked the incentive of former days in its prospecting activity. The question of crude oil prices and material will be left out of the present study in order to consider the more pertinent problem of the proper prospecting technique.

Except for the yet widely practiced procedure of "random drilling" most of the scientific prospecting activity is still directed toward the discovery of structural features with which oil and gas have been known to be indirectly associated. We have seen the days of surface geology where all that was needed in order to justify drilling was a good surface closure. Then core drilling and subsurface geology made their appearance with the search for subsurface highs not indicated at the surface. The first method has almost disappeared as providing sufficient scientific justification for the drilling of an exploratory well. Subsurface geology is, however, still greatly in use alone or in conjunction with the geophysical methods of structural prospecting such as the seismograph, the gravimeter and the magnetometer mainly inasmuch as subsurface geology dilineates the areas where structural accumulations might be present and serves to decide on the proper interpretation of geophysical measurements. In recent years, the prospective oil territories have seen a substantial decrease in the number of active geophysical crews because of the reduced efficiency of discovery or, in other words, because of the increase in the number of crew-months required per discovery of a commercially active oilfield.

Statistics of oil well drilling in the United States indicate that, on the average, one well in 25 wildcats drilled ever since the start of the industry in 1859 has opened up a new field. Up to 1937 about 1,000,000 wells had been drilled in the country of which about 6.5 percent were wildcat wells and the rest proved territory development wells. It is natural to expect that fewer wells would be dry in proved territory: 16 percent were dry in the former case whereas 96 percent were dry in the latter case.

Of late, statistics compiled by F. H. Lahee (1) on recent wildcatting in the country have indicated an improvement in the art of locating test wells even for apparently unscientific locations. According to Lahee, the statistics for wildcat drilling in the U.S.A. for recent years are given in Table I at the bottom of this page.

There is much food for thought in the figures presented in this table. To begin with, it may be seen that the resolving power of geophysics has been substantially decreased during the past five years whereas the resolving powers of geology or of geology-geophysics combined have remained sensibly at the same level. One may perhaps be justified to conclude that most of the structures which may be found by means of geophysics have already been found.

A further consideration of interest consists in observing that the combination of geological and geophysical information contributed to a greater percentage of successes than either one of them used singly. This is in accordance with the well known principle of probability which states that the probability of several independent events all happening at the same time is the product of the probability of their happening separately. This rule, coupled with the probability axiom that the probability of an event not happening is equal to one minus the probability of its happening, permits to calculate the probability of a well becoming a producer simultaneously by geology and geophysics. Therefore, the percentage of success obtained by the combination geology-geophysics should be equal to one minus the product of the probabilities of failing by geology and geophysics separately. This may be best expressed by equation (1):

Probability of a discovery by the combination geology-geophysics = 1 — (1— .1345) (1— .1975) (1) which gives .315 instead of .240 as indicated in Table I for the average of the four years. This discrepancy is due to the fact that every wildcat well location is also partly a random location. A more satisfactory check through equation (1) is obtained if one subtracts the randomness effect from the percentage of discovery figures given for geology and geophysics separately and thereby derive the pure contribution brought about by geology (p. geol.) and geophysics (p. geophy.) over the random contribution. This is obtained by solving the following two equations:

$$.1345 = 1 - (1 - .0575)\ (1 - \text{p. geol.}) \quad (2)$$

$$.1975 = 1 - (1 - .\$575)\ (1 - \text{p. geophy.}) \quad (3)$$

from which one finds:

p. geol. = .0818 or 1/12.2
p. geophy. = .149 or 1/6.75

The probability of success by combined geology-geophysics would therefore be obtained by the solution of equation (4)

$$\text{p. geol-geophy.} = 1\ (1 - .0575)\ (1 - .0818)\ (1 - .149) \quad (4)$$

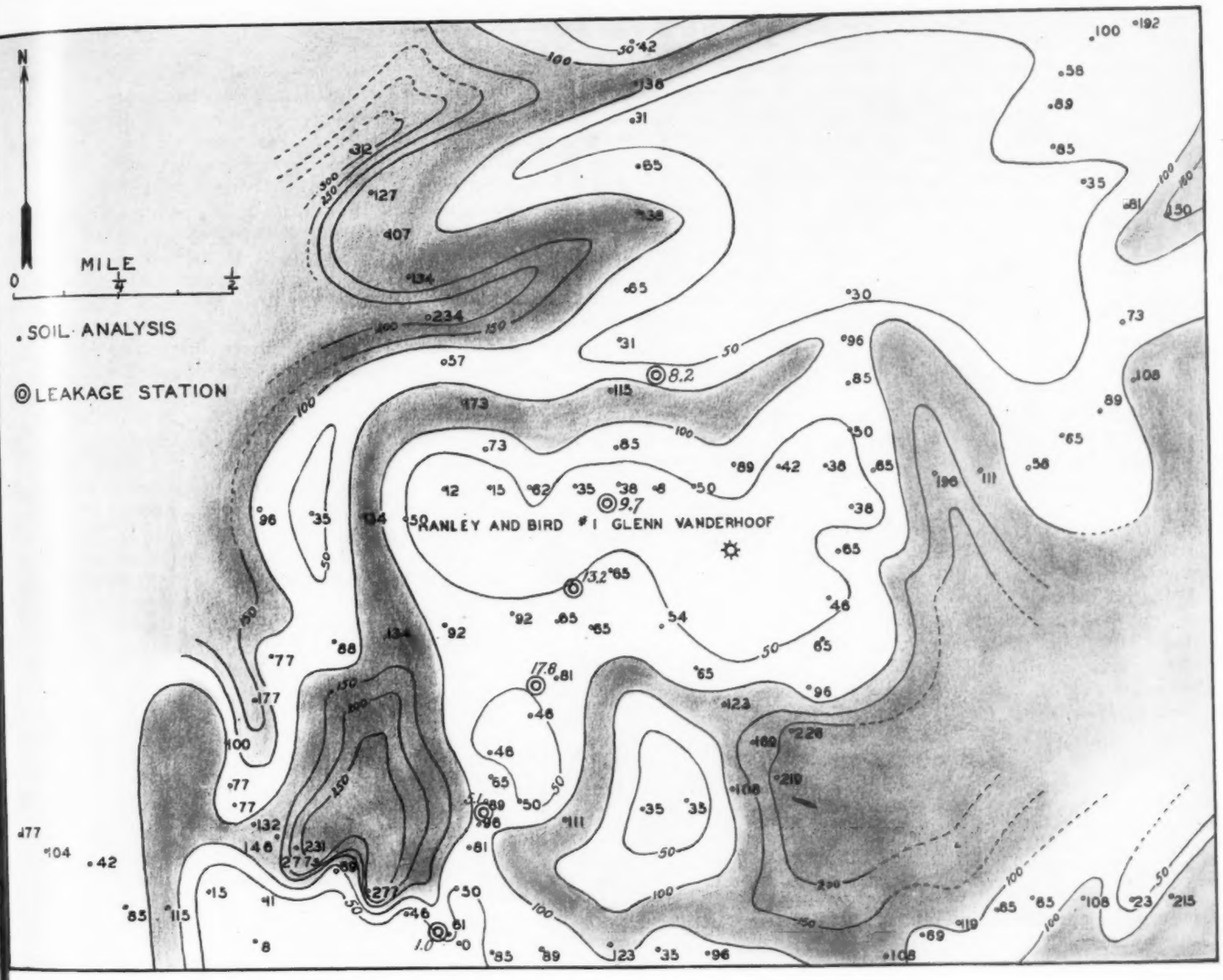
from which one obtains that p. geol.-geophy. = .263 which is much closer to the actual experimental figure of .240 as given by Table I.

The above derivations furnish the proper method for the calculation of the effect of additional scientific information before drilling on the probability of a wildcat well and there is no doubt

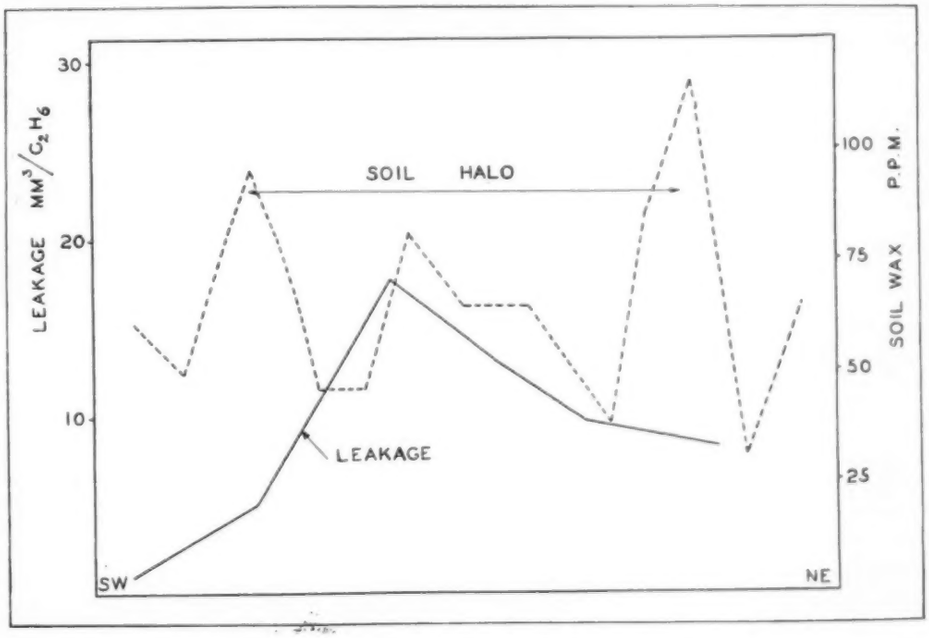
TABLE I

Wildcat Drilling Statistics According to Basis for Location

	Geology			Geophysics			Geology and Geophysics			Non-technical or Random		
Year	Producer	Dry	Probability of Success	Producer	Dry	Probability of Success	Producer	Dry	Probability of Success	Producer	Dry	Probability of Success
1937	116	861	.119	82	240	.254	15	66	.185	17	278	.058
1938	192	1041	.155	78	252	.236	31	69	.310	44	535	.074
1939	135	1006	.118	69	400	.147	13	40	.246	43	666	.061
1940	198	1204	.141	100	446	.183	22	81	.214	35	797	.042
Total	641	4112	.1345 or 1/7.45	329	1338	.1975 or 1/5.07	81	256	.2400 or 1/4.17	139	2276	.0575 or 1/17.4



Above, a comparison of results achieved in Steuben County, N. Y., by geodynamic prospecting and soil analysis. Right, a SW-NE cross section through the above map of Hartsville and Canisteo townships illustrating the results of both methods.



in the writer's mind that the rules which govern the calculus of probability should be used in determining the relative values of the oil prospecting tools at hand. An attempt to this end has been made in this paper, particularly with a view of establishing the value of a prospective method of high resolving power such as provided by Geodynamic Prospecting recently introduced. (2) Over the short period of ten months this method has located five wells, three of which have proved commercial producers whereas one discovered a non-producible accumulation of 10,000 bbl. to the acre. Neglecting this partial success and taking the most unfavorable statistical ratio of successes at .6 by Geodynamic Prospecting and eliminating the random effect, as shown above, the pure contribution toward discovery provided by Geodynamic Prospecting

is calculated to be .578. The writer realized that the number of geodynamic tests are insufficient in order to establish the contribution provided by Geodynamic Prospecting in an absolutely reliable manner under all possible conditions. Yet, the predictions were made under most favorable conditions since all wildcat wells based on this method were located in Northern Pennsylvania where oil is found altogether in sand bars, shore lines, pinch-outs, and the like.

TABLE II

Pure Resolving Power of Various Prospecting Tools

Tools	Pure Resolving Power
Random Drilling	.0575
Geology	.0818
Geophysics	.1490
Geodynamics	.578

For the purpose of comparison, Table II gives the pure resolving power of the various classes of oil prospecting tools on which statistical information is available to the writer.

In the oil prospecting campaign which is about to start in the search for new oil fields so that an adequate reserve of crude may be maintained in order that the armed forces of the United States and its allies may count on an uninterrupted supply, it is imperative to use a discovery method or a combination of discovery methods which will provide the highest resolving power at the lowest cost. This will permit an economy of man-power as well as of badly needed material and equipment, particularly steel. It is estimated that 50 to 100 tons of steel are used in the drilling of an average dry well whereas in order to maintain an adequate rate of discovery during 1942 and during the following war years an average number of 7,500 dry holes will have to be drilled annually if the search for oil remains at the same level of success as in the past. This waste of effort, equipment and energy may well add up in terms of steel tonnage to close to 1,000,000 tons per year if one takes into account the wear and tear on equipment used in prospecting, servicing, drilling, casing, etc.

It is, therefore, imperative that the prospecting activity be made with the method or combination of methods requiring the least expense and affording the highest resolving power. In order to reduce the discussion of this problem to numerical determination of a new unit, or concept, is here introduced: i. e. the "cost per unit of resolving power per acre." The concept is somewhat arbitrary inasmuch as it is equal to the ratio of the surveying cost per acre divided by the resolving power or probability coefficient of the discovery method used. Therefore, if the cost per acre of a survey is c and the resolving power of the method used is p, the cost per unit of resolving power per acre is c/p. This concept permits a comparison between the various possible prospecting methods or combination of methods which may be used in a wildcatting campaign. By way of example, Table III shows how such a computation may be carried out for the various methods indicated on Table II. For a more complete analysis of the problem a break-down into the resolving power of the various prospecting classes should be available such as in surface geology, sub-surface geology, core drilling, reflection seismograph, torsion balance, gravimeter, magnetometer, resistivity methods, soil-analysis, soil-air analysis, etc. This break-down must further be available over a number of years, (four to five at least) as the resolving power calculated for one year may be highly erroneous due to the limited number of tests drilled as a result of a particular method in a given year. When a large number of tests is available in widely scattered areas a reliable resolving power may be computed as the errors are likely to compensate each other. It is regrettable that the only statistics of this type published yearly by Lahee (1) do not provide this break-down. Therefore, Table III may only point the way to the proper solution of an adequate choice of the prospecting technique for minimum cost and maximum returns.

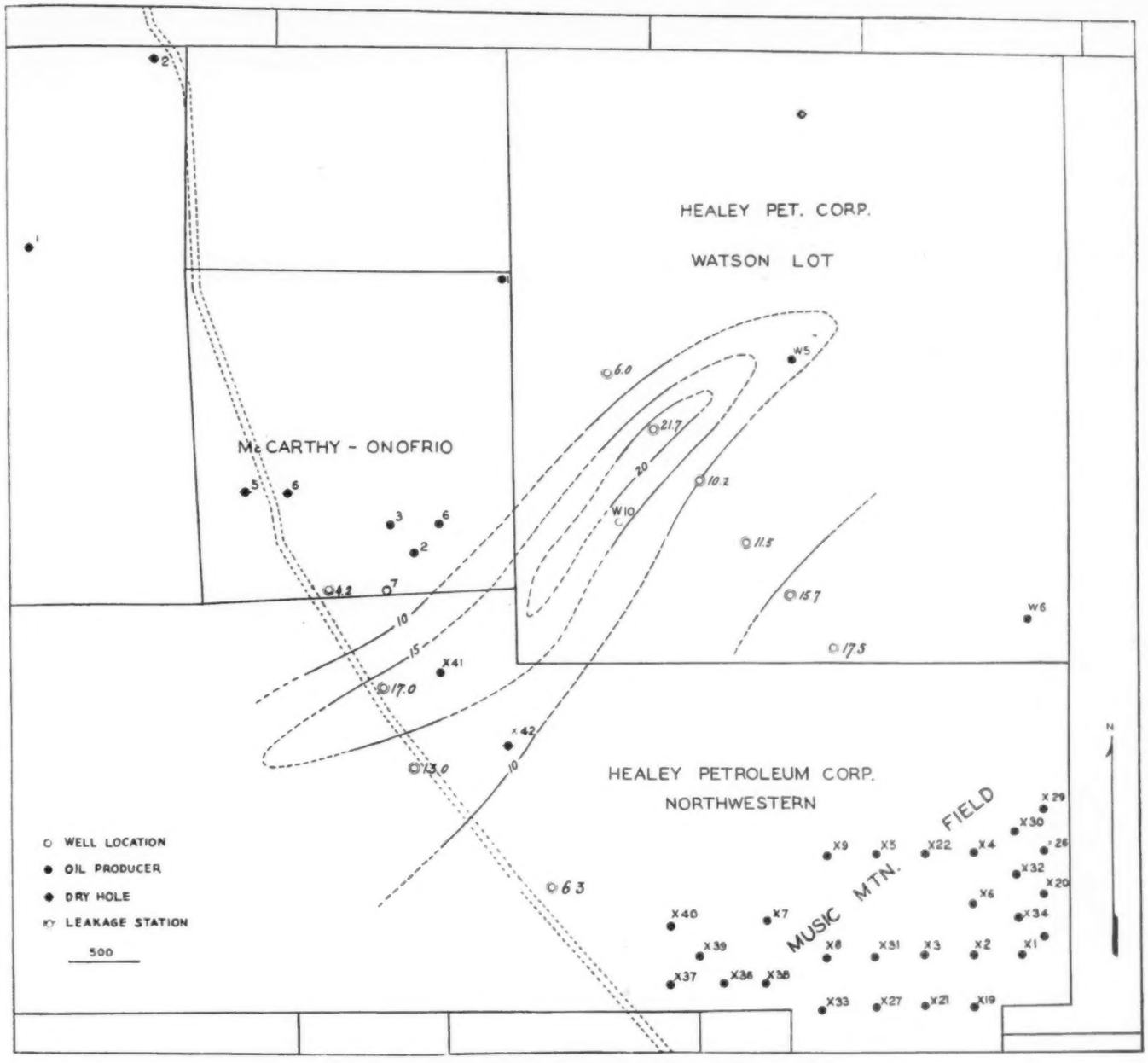
The second column of Table III gives the combined resolving powers of various combinations of prospecting tools enumerated in the first column. The third column gives the estimated average cost per acre of prospecting by these methods or combination of methods. The fourth column shows the variations in the cost per unit of resolving power per acre for various combinations of prospecting tools. The last column is perhaps the most enlightening because when a wildcatter purchases the services of a consulting organization selling a prospecting service what he really purchases is resolving power of his underground conditions. None of these services are perfect as far as the prediction of oil and gas accumulations are concerned and in order to reduce his risks he is inclined to have the prospective area surveyed by several organizations using different techniques. The general procedure should be, and generally is, to use the cheapest technique first which is that which has the lowest cost per unit of resolving power per unit area. Therefore, the first temptation is to use random drilling for which the exploration costs are nil or practically so. This, perhaps, explains why random drilling is still so popular. According to Table III, the next method which should be used is Geodynamic Prospecting as its cost per unit area and per unit

TABLE III

Cost of Unit of Resolving Power per Acre and of Added Information

Discovery Method or Combination	p Resolving Power of Method or Combination	C Estimated Survey Cost per acre	C/p Cost per unit of Resolving Power in Dollars per acre	$\frac{C}{p}$ Cost per Unit of Increased Resolving Power in Dollars per acre for
Random (R)	$\frac{1}{17.5} = .0575$	0	0	
Geology (Gl) ...	$\frac{1}{12.2} = .0818$	.25 (a)	3.05	
R + Gl	$\frac{1}{7.45} = .1345$	.25	1.86	Gl over R $= \frac{1.00}{.1975-.0575} =$ $3.2
Geophysics (Gp) .	$\frac{1}{6.75} = .1490$	1.00 (b)	6.75	Gp over R $= \frac{1.00}{.261-.1345} =$ $7.1
R + Gp	$\frac{1}{5.07} = .1975$	1.00	5.07	Gp over (R + Gl) $= \frac{.25}{.1345-.0575} =$ $3.9
R + Gp + Gl . $1 - \frac{4.07}{5.07} \times \frac{11.2}{12.2} = .261$		1.25	4.80	Gl over (R + Gp) $= \frac{.25}{.261-.1975} =$ $3.9
Geodynamics (Gd)	$\frac{1}{1.73} = .578$	.35 (c)	.606	
R + Gd	$\frac{3}{5} = .600$	.35	.585	Gd over R $= \frac{.35}{.600-.0575} =$ $0.6
R + Gl + Gd ...$1 - \frac{2}{5} \times \frac{11.2}{12.2} = .632$		.60	1.115	Gd over (R + Gl) $= \frac{.35}{.632-.1345} =$ $0.7
R + Gp + Gd ..$1 - \frac{2}{5} \times \frac{5.75}{6.75} = .659$		1.35	2.05	Gd over (R + Gl + Gp) $= \frac{.35}{.687-.261} =$ 0.8
R + Gl + Gp + Gd $1 - \frac{2}{5} \times \frac{5.75}{6.75} \times \frac{11.2}{12.2} = .687$		1.60	2.33	Gl over (R + Gd) $= \frac{.25}{.632-.600} =$ $7.8
				Gd over (R + Gp) $= \frac{.35}{.659-.1975} =$ $0.7
				Gl over (R + Gd + Gp) $= \frac{.25}{.687-.659} =$ $8.9
				Gp over (R + Gd) $= \frac{1.0}{.659-.600} =$ $17
				Gp over (R + Gd + Gl) $= \frac{1.00}{.687-.632} =$ $18

(a) Includes detailed surface and subsurface geology (well cutting studies and core drilling.)
(b) Cost based on continuous profiling by seismograph reflection shooting along section lines only.
(c) Based on a quarter mile station spacing.



Contour map of ethane leakage over a Sliverville sand lens recently discovered by geodynamic prospecting near Bradford, Penn.

of resolving power are the lowest. As Geodynamic Prospecting is not 100 percent correct, the wildcatter should purchase some added information in the form of a different technique for which the added resolving power will be the lowest per unit. From the last column of Table III one notices that Geology is the least expensive per unit of resolving power added. If further corroboration is needed to justify drilling, geophysics would be the next and last in line.

From the above considerations a certain number of conclusions should be made concerning the proper planning of a prospecting campaign:

(1) Geodynamic prospecting should be used preferably as the first scientific step in surveying a prospective territory for oil and gas rather than a detailed geologic survey. (2) Geodynamic prospecting appears as an economical prospecting technique of high resolving power. (3) The second step in a prospecting campaign should be to use the surveying technique which offers the lowest cost per added unit of resolving power. (4) The use of a very low resolving power exploration method following a survey by a method of high resolving power appears economically unsound as the cost per unit of resolving power for the added information becomes extremely high.

REFERENCES

1. F. H. Lahee—Wildcat Drilling in 1937—A.A.P.G. Bull. Vol. 22 (6), June, 1938, pp. 645-48
Vol. 22 (9), Sept., 1938, pp. 1221-35
—Wildcat Drilling in 1938—A.A.P.G. Bull. Vol. 23 (6), June, 1939, pp. 789-94
—Wildcat Drilling in 1939—A.A.P.G. Bull. Vol. 24 (6), June, 1940, pp. 953-58
—Wildcat Drilling in 1940—A.A.P.G. Bull. Vol. 25 (6), June, 1941, pp. 997-1003

2. Sylvain J. Pirson—Measure of Gas Leakage Applied to Oil Search—The Oil and Gas Journal, Feb. 20, 1941, pp. 21-32
—The Geodynamic Process—The Producers Monthly—May, June, July, August, 1941
—Progress in Geodynamic Prospecting for Oil and Gas Fields—API Meeting—April 17-18, 1941. Pittsburgh, Pa.
—Recent Developments and Successes in Geodynamic Prospecting—The Oil Weekly—January 12, 1942, pp. 26-30

PRACTICAL MEASURES For Conservation of Men and

By John F. Dodge & D. L. Roberts

Head, Division of Petroleum Engineering — Instructor Petroleum Engineering

University of Southern California

FACED with circumstances virtually unique in the American picture, the oil industry today has been charged with tremendous responsibilities and duties. Ever increasing demands for new fuels, new lubricating oils, new chemical by-products and base materials are being made, while ever tightening restrictions on material and governmental permission to proceed with vital processes are springing into being as rapidly as governmental agencies are capable of turning them out. High octane gasoline, higher specification Navy fuels, the base materials for countless items from dye and explosives to rubber tires; the list is endless, and the quantities demanded increase by leaps and bounds. No war baby, but a development of normal times, the oil industry, unblessed with A-1-A priorities and green-light governmental permissions, is not even in a favorable position with regard to labor. Unfortunately, few important jobs in the oil industry may be done by raw recruits who can be told to push the button and pull the lever. Even the physical labor unit of the fields—the drilling crew—requires adaptability and skill not developed in a few weeks or months of school and shop practice. Refining, managing, sales, research and control, production, development and exploration—all are specialized skills and professions. Men experienced in these positions are not replaced simply by hanging out a "Man Wanted" sign.

In the face of such quixotic conditions, the industry's task would be easier if there were no aftermath to consider, but this consideration should be one of the most important bases of judgment when decisions of policy are being made. One of the most important of these questions is that of maintenance of a healthy and proper ratio of reserves as against withdrawals. As in more normal times, geophysics, areal geology and the work of the land and lease departments, as well as routine developmental engineering play their part, and a very important part, but "the drill still finds the oil."

The problems of the drilling department have been multiplied and heightened by the factors touched on in the introduction to this article. Two of these—obtaining labor and supplies—are perhaps the most pressing. Fortunately, the aspect of the labor situation is not so dark as that of the others; fortunately, because in the writer's opinion, it has greater potentialities for difficulties than the other. Chief requirements of men who perform and supervise drilling operations are experience, level headedness and technical training and skill. It is the author's opinion that a good back log of such men exist in the persons of the older hands, usually drillers, tool pushers and even those who have been more or less incapacitated in the past and assigned less arduous positions as pumpers and boiler men. By virtue of age and dependencies, these men are serving best in their present positions, rather than in the armed forces. Too, few of them seem to be changing occupations. Seniority, and the peculiar pride in their craft which seems to affect most of them, as well as the satisfactory wage scales, have tended to keep them at their jobs. It is obvious, however, that better utilization of both labor and material must be made. Men who have been relegated to less exacting positions because of some physical impairment but who are still capable of a great deal of work, should be recognized as potential material for replacement of younger men who are removed by circumstances. In some cases a series of graduated steps of replacement may be possible, bringing men from retirement to take the places of oilers, gaugers, pumpers and roustabout foremen who are advanced or returned to the drilling rig where they were once active.

So far as material and ways of doing are concerned, some utilization and conservation methods which have been regarded up to now as good practices will probably become musts. Of these, it is considered that one of the most important is drill pipe and tool joint care. Some of the best methods for preventing undue deterioration are as follows: (1) Inspection for notches, swollen pipe and incipient washouts by the crew when coming out of the hole. Though this is supposedly standard practice, it is very often done slightingly, and sometimes not at all. (2) Proper lubrication of joints with the correct type of dope, and prevention of the common practice of diluting the dope with oil so stands will spin up better. There is no doubt that this practice is often directly responsible for washouts. (3) Refacing of tool joint faces and threads on the rig services before the first sign of a washout. (4) Maintenance of tool joint diameter by hard facing, sleeving, or the spiral puttee method of rebuilding. (5) Use of proper drill pipe protectors. (6) Proper drilling technique, which pays for itself in straighter hole and less grief.

Chains present further opportunities for increased savings. Inspection for missing safety keys and rollers furnishes ample warning of an increased rate of deterioration. When this is found, it may very often be traced to one of the following causes: (1) Insufficient or improper lubrication. (2) Mis-alignment of sprockets. (3) Bad or poorly fitting sprockets. (4) Use of an improper type of chain, or of too light a chain for the service. False economy shows up rapidly when slow speed chain is used on high-speed drives with resultant failures.

Pumps are common sources of losses which in themselves may be minor, but whose totals can be very large. Careful supervision, and the signing of a written report by one member of the crew charged with responsibility for the pumps, can often reduce pump maintenance costs greatly. The cost of new junk rings and packing is very small compared with that of a new rod, yet often repacking is delayed until the rod is badly cut, when the packing must be removed anyway. Inspection by a skilled man may often detect a partially cut-out liner before expensive damage to head and body casting occurs.

The simplest preventative measures on a rig pertain to high pressure plug valves. Only three simple operations are called for: (1) Choice of correct valve for the service. (2) Sufficient correct lubrication. (3) Proper adjustment of the plug. This is almost universally disregarded by drilling crews whose favorite procedure is to cinch down the adjusting collar after using a valve, under the misapprehension that they are prolonging valve life by so doing.

During times when there is urgent need for conservation of all material, these measures, when applicable, certainly more than repay the necessary expenditure of time and material.

Running surface casing in a California field. The close spacing and deep wells of some of the fields in California will be drastically limited by the 40 acre spacing rule recently issued by the OPC. Photo by Orville Logan Snider.

and Material In Oilfield Operation

The Tulsa Chapter of the Nomads organization recently elected officers for the year 1942; the newly elected officers are pictured above, from left to right: Paul Fitzgerald, vice-president; W. G. Green, regent; C. O. Wilson, president; H. M. Cosgrove, secretary-treasurer; and Fred E. Cooper, regent.

whose products are to be found in oilfields in all parts of the world. In addition to pumps, sucker rods, gauges and numerous other oilfield supplies the Axelson Manufacturing Company is now producing a large volume of aviation parts for Allied war planes as well as machine tools, heavy duty lathes and accessories.

In reviewing the fifty year span of the company's existence, the Axelsons may well be proud of a record, which, starting in 1892 with a $1200 machine shop, has grown into an industry supplying oilfields in all parts of the world.

Above. Captain Michel T. Halbouty, well known Gulf Coast consulting geologist, who recently reported to the staff officers school at Ft. Benning, Ga. for active service. Capt. Halbouty obtained a commission as second lieutenant in 1930 upon his graduation from Texas A. & M. Since obtaining his masters degree in the following year Capt. Halbouty worked with the Yount-Lee Oil Co. as chief geologist, a post which he later occupied with the Glenn H. McCarthy Company. Since 1937 he has pursued his career as a consulting geologist and was well known on the Gulf Coast, in the Mid-Continent and in New York for his geological studies and his numerous papers published in the oil industry press and delivered at technical meetings.

FOREIGN OIL LEGION

IN 1942 with the foundries, machine shops and assembly lines of the Axelson Manufacturing Company devoting their main energies to essential war time production and maintenance, J. C. Axelson, President and General Manager of the concern announces the celebration of the company's Fiftieth Anniversary. In the spring of 1892 C. F. Axelson and his brother G. A. Axelson, respectively an expert machinist and expert molder, in Topeka, Kansas, purchased a small machine shop at Santa Ana, California. The firm started in business under the name Acme Iron Works, and for seven years devoted their energies to a number of unusual production problems. The attention of the company was first attracted to the petroleum industry with the manufacture of the Parker pump, which was the first oil well pump to employ the now standard metal-to-metal principle. These pumps proved to be satisfactory in handling low gravity oil containing a high percentage of sand, particularly in the Bakersfield territory. The reputation of the Axelson brothers in the petroleum equipment business spread rapidly throughout the state and today the sons of the founders, J. C. Axelson, President and General Manager, and D. F. Axelson, Vice-President, are carrying on a petroleum equipment manufacturing business

C. F. Axelson *G. A. Axelson* *J. C. Axelson* *D. F. Axelson*

Voluntary Destruction in East Indies

(Continued from page 35)

about 1,850,000 tons a year. To put such wells out of action, various methods were used. Some, for example, were plugged, and it might be mentioned that it is quite possible to plug a well so that it can never again be opened without being completely re-drilled. The machinery, likewise, is not so compact that it can be disposed of by means of a single explosive charge. A modern refinery will cover anything up to a square mile, while each unit of the complicated chain of condensing and distilling apparatus would need almost individual attention to be destroyed thoroughly. Oil tanks, pumping stations, power-plants, pipe-lines, store-houses, and all the other essentials of a modern installation would also necessitate a vast amount of personal work to bring about complete destruction, and, as all our Dutch oil centers were complete, down to the last amenity and convenience—even to swimmnig-baths, canteens, playing fields, and cinemas—total destruction meant total effort. And believe me, the Dutch would not even leave a swimming-bath for the Japs. Each area was turned into an ocean of flame which gradually changed into a dismal desert of ruin."

By destroying the Tarakan, Balik Papan, and Palembang oil-centers the Dutch cut off 88 percent of the total oil available in the East Indies. Palembang alone produced about 2,500,000 tons a year for the Royal Dutch Company, while Brandan in the Northwest of Sumatra had an output of about one-third that of Palembang. It is certain that Brandan has now been destroyed also, for it was closed down immediately Penang fell, owing to the danger of getting tankers through the Malacca Straits. Expressed in oil this is a tremendous blow to Japan, although expressed in money—both investment and income—it is admittedly a terrific blow to the Dutch. (Note—Since this interview the Tjepoe oilfields in East Java have also been put to the torch.)

Asked whether there was any hope of the Japanese patching up these wells and getting at least a small quantity from them within a short time, Mr. Kessler smiled grimly.

"I don't think so," he said. "At Tarakan, of course, where the oil is such that it need not be refined, they might within a few months be getting a small quantity of crude fuel. But elsewhere, not much hope. As I have already said, the machinery for oil production is complicated and massive. The Dutch had to import practically everything from Holland, England or America, and it took years to obtain it and erect it. I very much doubt, even if such machinery were available, whether Japan could transport it and erect it without the Allied fleets or air forces stopping their little game. Even drilling new wells takes a long time and needs elaborate machinery. And I think Japan will have to do a mighty lot of drilling before she can hope to get even small quantities of oil.

"Long pipe-lines, too, need time and skill to construct. Personnel, also will be a problem. Every phase of oil production is highly technical. And Japan has not yet had enough experience to hope to send an army of well-trained technicians into the occupied islands to start work in the near future, although I admit she probably has a few available. Even if Japan could get the men and even if she obtained the help of German technicians, I very much doubt whether she would get the chance to restore these wells as long as there is an Allied Air Force.

Kessler was asked if he knew of any precedent on which an estimate could be made. He suggested a little research into the case of the Rumanian wells which were destroyed in 1916—although he pointed out, that, as the work was carried out hastily, in two or three days, it was not nearly so thorough. At the best it was only half-destruction and nothing like the devastation which the long preparations in the Dutch East Indies made possible. Yet even the Germans were not able to open the first Rumanian oil well for two months after they took over the territory, and although a number of the wells had actually been left intact, it was almost two years before about 425 wells, out of a total of 950, were in normal production. And even at the time of the Armistice, the Rumanian fields were yielding only about 1,000,000 tons a year, compared with the pre-destruction output of 1,890,000 tons. This, however, was regarded as a great feat, made possible, says one oil expert, "Only because the Germans tackled the task with the utmost skill and enthusiasm and because they had at their disposal experts with an extensive knowledge of local conditions."

The Japanese are not so favorably placed as the Germans were, either in the matter of expert experience, men with local knowledge, or facilities for transporting new machinery, apart from the vast difference in the nature of the destruction.

As to whether the Dutch would be able to bring the wells back into production, Kessler pointed out that so much depended upon the course of the war, and as to how soon the Allies could begin an offensive. But once the war is won, he said, "There is little doubt that what the Dutch have done once, they can do again. The enterprise, skill, and determination that produced this oil wealth during the past half century will once again make the oil centers of Tarakan, Balik, Papan, Brandan and Palembang thriving sources of the vital commodity. And it certainly will not take so long as the original development since there are fifty years of experience to draw on." "But," he added, "The voluntary destruction of many millions of pounds worth of property will certainly provide yet another great problem to face when the period of reconstruction begins."

Asked how the personnel had fared at these centers, the oil executive said: "So far we have heard little about Palembang, where we had 355 European and 7,350 Asiatics employed. We know that a number of the men were in the Army and must have participated in the great delaying actions, while it is likely that many of the others escaped, after they had carried out the destruction. It is also reported that a number of the women managed to get away. At Tarakan, three of our Dutch staff were killed in action and one was wounded. About 43 men and 19 women are now prisoners of war, having been compelled to remain there while the destruction was being carried on. Two others got to Java and one to Borneo. At Balik Papan one man was killed, 133 escaped to Java, 65 were last heard of on their way to Java, and of 23 who were in the N.E.I. Army we have had no information. About twelve Dutch women were left in Balik Papan and are now in Japanese hands.

"We do know that many of our employees played a great part in holding off the Japs until the last building was blown up and the last well was plugged. And it is to the eternal credit of their womenfolk that most of them stayed to the end with the men to do what they could in carrying out this duty of preventing the Japanese from getting any oil. I can only hope that the Japanese pledge of Bushido, or military chivalry, will be honored with these brave women."

CORRECTION

THROUGH an unfortunate mistake in the translation from Spanish to English of an article appearing in the September 1941 issue of WORLD PETROLEUM entitled "Petroleum Legislation in Ecuador," by Dr. Enrique Coloma Silva, Director General of Mines and Petroleum in the Republic of Ecuador, the impression was conveyed that the petroleum industry in that country is considered a public utility, and as such can be expropriated in conformity with the respective laws. Dr. Coloma actually stated in the Spanish version of his article that the petroleum industry in Ecuador as a public utility had the right to condemn territory necessary to its operations: in other words, like a public utility in North America, the oil industry in Ecuador has the privilege, subject to government approval, of exercising the right of eminent domain. The exact translation of Dr. Coloma's Spanish manuscript reads, "The petroleum industry is declared a public utility, and as such, it enjoys the right of expropriation in its favor . . . "

The editors regret this mistake in translation since the obvious intention of petroleum legislation in Ecuador as interpreted by Dr. Coloma in his article in the September issue is to encourage development by private industry.

WORLD OIL PRODUCTION

Figures in U. S. barrels of 42 gal.—Conversion ratios used are weighted averages for individual countries

	U. S. BARRELS				METRIC TONS			
	Feb. 1942 Preliminary	February 1941	Jan.-Feb. 1942	Jan.-Feb. 1941	Feb. 1942 Preliminary	February 1941	Jan.-Feb. 1942	Jan.-Feb. 1941
United States	115,559,000	100,791,000	243,821,500	211,438,000	15,635,097	13,637,000	32,988,973	28,608,000
Soviet Union	17,458,000	18,410,000	35,886,000	37,424,000	2,394,788	2,525,000	4,922,634	5,134,000
Venezuela	14,601,480	14,931,677	36,355,530	30,180,734	2,168,000	2,217,027	5,398,000	4,481,178
Iran	5,986,232	6,127,200	12,582,288	12,677,200	794,141	812,842	1,655,356	1,683,099
Netherlands India: Sumatra	.....	3,300,000	3,410,000	6,645,000	.....	422,481	436,563	850,723
Borneo	.....	1,000,000	.....	2,070,400	.....	128,025	.....	265,063
Java	.....	500,000	500,000	1,037,600	.....	64,012	73,223	132,838
Molucca and Other	.....	58,000	.....	118,300	.....	7,425	.....	15,145
Rumania	3,151,484	2,982,848	6,457,484	4,943,956	427,320	404,454	875,591	670,367
Mexico	2,605,000	3,232,000	5,488,000	7,217,000	382,526	474,596	805,874	1,059,765
Iraq	1,000,000	950,000	2,500,000	1,950,000	133,672	126,988	334,179	260,660
Colombia	1,886,836	1,637,000	4,181,479	3,637,000	263,157	228,312	568,850	493,305
Trinidad	1,616,664	1,700,000	3,406,548	3,500,000	227,379	239,100	480,527	492,265
Argentina	1,661,912	1,682,103	3,501,886	3,509,763	236,740	239,616	498,844	499,966
Peru	1,036,000	1,000,000	2,183,000	2,000,000	136,766	132,013	288,185	264,026
Bahrein	560,000	562,000	1,180,000	1,190,000	76,419	76,692	161,025	162,391
Burma	298,000	585,800	957,990	1,234,351	41,160	80,912	132,318	170,491
Canada	761,964	737,313	1,605,567	1,539,965	96,967	93,830	204,322	195,974
Brunei	.....	449,763	.....	921,787	.....	59,055	.....	121,033
Great Germany: Old Reich	334,180	350,000	704,165	730,000	47,788	50,050	100,695	104,390
Ostmark	52,388	58,000	110,389	116,800	7,810	8,646	16,456	17,412
Slovakia and Moravia	8,120	9,000	17,110	18,800	1,196	1,326	2,520	2,770
Poland	210,000	300,000	442,500	620,700	31,306	40,437	62,644	83,664
Japan	205,296	218,000	432,588	436,000	29,203	31,010	61,534	62,020
British India	175,672	155,344	370,166	370,688	24,264	25,600	51,127	51,200
Ecuador	197,784	109,502	428,701	214,703	26,076	14,437	55,683	28,307
Saudi Arabia	280,000	467,900	590,000	935,800	38,210	63,851	80,513	127,702
Sarawak	.....	108,000	.....	216,000	.....	13,816	.....	27,632
Egypt	587,076	600,000	1,237,053	1,250,000	83,844	85,690	176,671	178,520
Italian Empire: Albania	98,616	115,000	213,595	240,000	14,781	17,236	32,014	35,971
Italy	3,360	3,900	7,080	7,900	417	484	879	981
France	37,016	35,000	77,998	75,000	5,192	4,909	10,940	10,519
Hungary	252,700	180,000	532,475	355,000	33,997	24,216	71,636	47,728
Bolivia	9,016	9,500	18,998	20,302	1,168	1,231	2,461	2,631
Other Countries	44,716	47,800	94,223	95,600	6,389	6,829	13,461	13,658
TOTAL	170,678,512	163,433,650	370,011,813	339,848,349	23,365,773	22,419,148	50,563,698	46,355,394

Official Crude Oil Production Figures from 1939 to 1941

	Daily Averages Bbl.		Daily Averages Metric Tons		Total Bbl.			Total Metric Tons		
	Jan.-Feb. 1942	Jan.-Feb. 1941	Jan.-Feb. 1942	Jan.-Feb. 1941	1941	1940	1939	1941	1940	1939
United States	4,132,568	3,583,695	559,135	484,873	1,404,182,000	1,353,214,000	1,264,962,000	191,377,000	182,904,869	171,152,192
Soviet Union	608,237	634,305	83,434	87,010	242,150,000	222,600,000	220,866,000	33,244,000	30,260,631	30,297,119
Venezuela	616,195	511,538	91,491	75,952	222,901,864	184,761,241	205,783,650	33,096,341	27,432,998	30,533,706
Iran	213,259	214,868	28,291	28,505	78,035,012	79,151,675	78,151,332	10,352,216	10,443,546	10,367,117
Netherlands India: Sumatra	57,797	112,627	7,399	14,419	40,827,050	40,586,986	41,557,013	5,226,865	5,172,209	5,320,320
Borneo	.....	35,091	.....	4,492	13,847,720	12,987,599	13,125,425	1,772,846	1,662,718	1,680,377
Java	8,475	17,586	1,085	2,251	6,734,781	6,514,462	6,568,714	862,218	836,982	842,237
Molucca and Other	.....	2,005	.....	257	720,786	731,746	836,114	92,277	93,569	107,047
Rumania	109,449	83,796	14,840	11,362	40,562,500	42,524,988	46,020,000	5,499,999	5,766,099	6,240,000
Mexico	93,017	122,322	13,659	17,962	41,200,000	40,314,787	39,428,141	6,049,927	5,843,395	5,794,035
Iraq	42,373	33,051	5,664	5,602	12,650,000	24,225,007	30,791,132	1,683,279	3,238,878	4,115,845
Colombia	70,873	59,949	9,885	8,361	24,441,566	25,592,890	23,857,000	3,408,853	3,569,434	3,327,336
Trinidad	57,738	59,322	8,121	8,343	21,210,644	20,218,566	19,270,256	2,983,215	2,842,918	2,710,515
Argentina	59,354	59,487	8,455	8,474	21,641,186	20,616,928	18,738,003	3,082,790	2,936,880	2,657,232
Peru	37,000	33,898	4,884	4,474	12,845,520	12,985,284	13,587,906	1,695,777	1,716,195	1,798,557
Bahrein	20,000	20,169	2,729	2,752	6,845,559	7,095,370	7,588,554	934,165	968,502	1,045,391
Burma	16,237	20,921	2,243	2,889	7,762,262	7,730,901	7,872,981	1,069,372	1,067,895	1,087,424
Canada	27,213	26,101	3,463	3,321	10,003,290	8,718,053	7,837,503	1,273,008	1,109,440	997,487
Brunei	.....	15,623	.....	2,051	5,551,743	5,729,374	5,767,227	728,959	764,006	768,320
Great Germany: Old Reich	11,935	12,373	1,707	1,769	4,437,647	4,543,955	4,487,491	634,584	653,590	647,337
Ostmark	1,871	1,980	279	295	692,240	718,494	693,247	103,195	114,045	109,904
Slovakia and Moravia	290	318	42	47	109,120	118,775	119,380	16,078	17,836	18,103
Poland	7,500	10,520	1,011	1,418	3,318,900	3,891,456	3,898,044	447,352	520,984	522,874
Japan	7,332	7,390	1,043	1,051	2,659,252	2,638,644	2,652,930	378,272	376,657	379,161
British India	6,274	6,283	866	868	2,269,650	2,249,835	2,332,467	313,488	310,596	322,160
Ecuador	7,266	3,639	958	480	1,560,998	2,349,015	2,312,118	205,800	309,686	306,824
Saudi Arabia	10,000	15,861	1,365	2,164	5,870,702	5,364,610	3,933,904	801,135	726,785	536,366
Sarawak	.....	3,661	.....	460	1,312,033	1,317,185	1,329,645	167,844	168,475	171,322
Egypt	20,967	21,186	2,994	3,026	7,658,627	6,053,367	4,603,797	1,093,773	846,514	657,570
Italian Empire: Albania	3,620	4,068	542	610	1,381,249	1,497,124	1,393,727	207,021	224,199	208,279
Italy	120	134	15	17	45,894	57,350	91,330	5,699	7,110	11,346
France	1,322	1,271	185	178	478,564	496,420	500,815	67,124	69,578	70,478
Hungary	9,025	6,017	1,214	809	2,473,552	1,755,000	815,248	332,748	236,025	109,896
Bolivia	322	344	42	44	120,748	110,484	100,885	15,649	14,249	11,998
Other Countries	1,597	1,620	228	231	580,787	580,001	578,036	82,968	82,779	82,300
TOTAL	6,259,226	5,745,719	857,269	786,807	2,250,731,440	2,150,041,572	2,082,452,045	309,305,837	293,328,272	284,908,175

Detailed monthly reports were published in February, 1942 issue.

WORLD PETROLEUM ABSTRACTS

Summaries of the Most Important Articles as Published in the Oil Press of the World Dealing with Technical and Economic Aspects of the Petroleum Industry — Edited by Dr. O. W. Willcox.

DRILLING

Developments in Pressure Coring Practice—I. S. Salnikov, in MINING MAGAZINE, Vol. 31 (1941), No. 9; pp. 441-442; 484-485.

Since 1939, when the first pressure core barrel was described by B. W. Sewell to the A.P.I., this device has shown itself indispensable for obtaining information not furnished by the conventional core barrel.

As operated in the latest type, the core, after being cut, is brought to the surface in a sealed chamber where it is kept under the same pressure that prevails at the bottom of the hole. This pressure is read on an accurate gauge; the pressure is reduced to atmospheric, and all mud in the tube is steam distilled to determine the amount of oil given up by the core when the pressure was released. The core is then analyzed to determine the usual data, such as porosity, permeability, saturation, water and salt content, etc. By including a tracer compound in the drilling mud and determining the amount of the tracer in the core, an estimate can be made of the degree to which the core has been polluted by the mud. By making a pollution correction a very clear picture of the original formation can be secured.

Without question, the great advantage of pressure coring lies in the determination of total fluid saturation as compared with residual saturation from conventional coring. While the data is still somewhat limited, some conclusions may be drawn. For example, a core taken from a 140-barrel well produced 20 cc.'s of oil; one from a 170-barrel well produced 25 cc.'s of oil; and one from 360-barrel well produced 40 cc.'s of oil. A definite trend in data is certainly apparent. From such information as this it is possible to build up a production index from pressure cores giving an approximate measure of the ability of wells to produce. Similarly studies of gas volumes produced by pressure cores indicate possibilities of important correlations.

It is difficult and for all practical purposes impossible, to evaluate reservoir fluid content from residual oil saturation data. At best, this information will indicate how much oil should remain in the reservoir upon depletion by dissolved gas drive with infinitely close spacing and maximum reduction in reservoir pressure.

OPERATION

New Method of Washing Gravel Packed Liners in Wilmington Completions—I. P. Sanders, in OIL & GAS JOURNAL A.P.I. SPECIAL, p. A.-107 (1941).

What is described as a strange type of well completion has been developed in the Los Angeles basin and has proved beneficial in at least one instance. The well would flow only by small heads, and these heads had to be induced by swabbing. The sand had no calcareous elements, so acidizing would do no good.

Evidently, the formation needed "breaking down," for which a precedent exists in squeeze cementing, an operation that is preceded by forcing clear water through the sand; this has been found effective in opening up a sand so that it will take more slurry and reduce the necessary pump pressure. From analogy with this process it was reasoned that the oil sand might be opened in a similar manner; obviously, water would not do in this case, so it was decided to try oil. After making suitable preparations at the tubing head, 500 bbl. of gas oil were circulated at a rapid rate to clean out drilling mud, water and cuttings; the casing was closed and a pressure of 900 lbs. was built up while 45 bbl. of gas oil were being forced out into the oil zone. After this operation the well was swabbed for 12 hours; the casing pressure then built itself up to 500 lbs., and flow through the tubing started against a back-pressure of 140 lbs. The well was then found capable of flowing unaided at the rate of 100 bbl. a day of 31-gravity oil through a 10/64 inch choke. Thus it appears that a new practice has been developed which may take its place beside acidizing and shooting as means for increasing the production.

PIPE LINES

Review of Methods Used in Reducing Internal Corrosion of Gasoline Pipelines—W. A. Schulze, L. C. Morris and R. C. Alden, before AMERICAN PETROLEUM INSTITUTE, 22nd Annual Meeting, San Francisco, November, 1941.

Within the last few years about 10,000 miles of pipelines have been built for conveying gasoline. Much of this mileage is relatively new, and experience with corrosion problems in transporting this product is not yet very extensive.

However, it appears that corrosion is extensive enough to warrant serious consideration and methods are being evolved to combat it. These methods are naturally directed toward counteracting the corroding agent which is oxygen, either free as in air or combined in water. The products of corrosion are mainly iron rust. Accumulation of rust and scale naturally restricts the capacity of the pipe, and where this occurs resort may be had to scrapers, but this does not eradicate the trouble at its source.

Since prevention is better than cure, attention has been given to reducing the air content of the gasoline. At one station use has been made of a new type of totally enclosed alleviator to exclude air from entering by way of the pumps, using ethylene glycol as a buffer liquid.

Since water especially, in the presence of oxygen (air), is a corroding agent, the gasoline may be dehydrated. One company reports using activated alumina as an absorbing agent for water until 1939, when it was replaced by Florite, a commercial bauxite, which is periodically regenerated by heat. Reduction of the moisture content by 40 to 50 per cent is reported. This pipeline (in Kansas) is 178 miles long, and the engineering department reports that there is little question that material benefit has been derived from this partial dehydration of gasoline and light petroleum products transported by the line; at any rate the original flow factor has been consistently maintained.

Aside from these direct attacks on the corroding agent, attempts have been made to neutralize its effects by the use of oxidation inhibitors. Two companies report on the use of sodium sulphite, which is injected as a solution of one pound of the sulphite in a gallon of water. In both these instances the results have not been convincing.

The Phillips Petroleum Co. has been experimenting for several years on the use of an organic oxidation inhibitor called Rokon (mercapto-benzothiazole) in a 110-mile line between Borger and Laverne in Oklahoma. The test method used in these experiments was to insert strips of iron inside the line at pumping stations or river crossings. The rate of corrosion of these pieces was ascertained by loss of weight when the inhibitor was used and not used. As a check, the amounts of sediment collected in the sediment traps placed on the intake side of each station were measured. The test specimens showed a clear benefit from the use of the inhibitor, and this indication was confirmed by an equivalent decrease in the amount of sediment taken from the traps. A somewhat similar experience is reported by another company which, however, makes complaint of the high cost of Rokon and the injection expense.

On this complaint the authors of this paper observe that certain intangible benefits should be taken into account. Among these is the fact that iron oxide in turbulent motion in the presence of oxygen tends to decrease the gum stability of the gasoline, hence an extra expense for more gum inhibitor, which the use of Rokon will make unnecessary. Other considerations also speak for the use of Rokon in spite of its high cost.

Temperature of Natural-Gas Pipe Lines and Seasonal Variations of Underground Temperatures—W. M. Deaton and E. M. Frost, Jr., in U. S. BUREAU OF MINES REPORT OF INVESTIGATIONS NO. 3590, October, 1941.

The formation of gas hydrates in natural-gas pipe lines depends on temperature and pressure conditions in the lines as well as on the presence of condensed water. The operating pressure in a pipe line may be determined easily and usually is available from the records of operation, but the temperature seldom is known. In cooperation with the American Gas Association, the Bureau of Mines, in its investigation of gas hydrates, conducted a pipe-line-temperature survey and studied underground temperatures at depths at which pipe lines

ordinarily are buried and the relationship of these temperatures to prevailing atmospheric conditions.

For obtaining the temperature, recording equipment was installed on a 22-inch natural-gas pipeline originating near Amarillo, Texas, and extending northwestward to Denver, Colorado, a pipeline distance of 340 miles. The underground temperature observations extended over a period of about four years.

The general result is a finding that the temperature of the lines and of the gas therein is essentially the same as the temperature of the ground at a depth corresponding to that of the center of the pipe, unless there are disturbing influences, such as compressor stations, river crossings, or abrupt changes in the depth of the pipe line. Changes in the temperature of buried pipe lines may lag behind changes in atmospheric temperature by several days, and this lag depends on the depth to which the pipe line is buried.

Records of ground temperatures ranging from the surface to a depth of 10 feet are presented in the report. They show, for the areas studied, that the lowest temperatures reached at depths of 3 to 10 feet occur during February or March and that the highest temperatures at these depths occur during August or September.

The kind of soil affects the rate of heat transfer through it and influences the rate of change of the underground temperatures; moisture in the soil also influences the rate of heat transfer. However, these factors were not known well enough to justify evaluation of these rates.

Engineering Economics of Long Petroleum Pipe Lines—Edgar G. Hill, in PETROLEUM TECHNOLOGY, 1942, Technical Publication No. 1433; 13 pages.

This paper discusses the fundamentals of pipe line design from the economic and engineering viewpoints; also the effect of the character and volumes of fluid transported, and effect of the load factor at which they are operated on the unit costs of transportation. Emphasis is laid on capacity in relation to operating cost; specifically, the cost of a 12-in. line with a capacity of 50,000 bbl. of crude per day is estimated at $21,900 per mile at today's price levels, equivalent to 43.8c per mile per barrel of daily capacity.

A 24-in. line with a daily capacity of 295,000 bbl. of the same crude is estimated to cost $60,200 per mile, equivalent to only 20.4c per mile per barrel of daily capacity. The capital costs of transporting oil through the 24-in. line therefore are only 46.6 per cent as much per barrel of capacity as for a 12-in. line, and in comparison with capital costs of transporting oil through 8 and 10-in. lines, the economy in the use of lines of very large capacity is even more pronounced.

The great influence of load factor on over-all costs of pipe-line transportation is primarily because it costs about the same to own and operate a pipe line of a given size and length regardless of the percentage of full capacity at which the line is being used. The capital costs, of course, are constant in dollars and the same applies to much of the administrative costs and to most items of pipe-line routine operation and maintenance. The pumping-station fuel will vary about in proportion to the quantities handled and the same is true to some extent of maintenance of pumping machinery, but probably 80 percent of the total operating costs of a pipe-line system, including capital charges, are entirely independent of the volume handled.

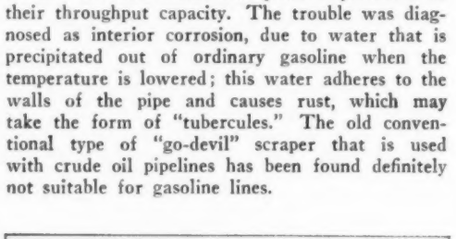
It will be readily seen, therefore, that in order to realize the full potentialities of pipe lines in reducing the transportation costs of petroleum and its products, not only are large-diameter lines effective but such lines must be operated at high load factor; that is, the average daily throughput divided by the throughput for which the line was designed must show a quotient representing a load factor as near unity as possible. Storage tanks along the route are commonly used to increase load factor and the use of products lines to handle furnace oil in winter, when gasoline consumption is usually lighter, is, of course, a valuable help in the same direction.

This means that in designing pipe lines great care should be taken to make sure that they are built not so large in comparison with the annual volume of crude or products expected to be handled through them that it will be difficult to operate them under an annual load factor of 75 percent or better.

A large line that would operate at 100 percent load factor with a cost of say 3c per barrel per 100 miles would probably show a cost of about 3.25c at 90 percent load factor, 3.63c at 75 percent and 5.4c at 50 percent, so that good load factor is fully as important as large volume in reducing costs of pipe-line transportation.

Experiences with and Effect of Use of Scrapers on Internal Corrosion of Gasoline Pipelines—D. E. Sullivan, before AMERICAN PETROLEUM INSTITUTE, 22nd Annual Meeting, San Francisco, November, 1941.

When the construction of gasoline pipelines was begun in the early 1930's the problem of interior corrosion of such lines was not seriously anticipated. But after the first of these lines were put in operation they soon showed an increase in the friction of flow with consequent impairment of their throughput capacity. The trouble was diagnosed as interior corrosion, due to water that is precipitated out of ordinary gasoline when the temperature is lowered; this water adheres to the walls of the pipe and causes rust, which may take the form of "tubercules." The old conventional type of "go-devil" scraper that is used with crude oil pipelines has been found definitely not suitable for gasoline lines.



After reviewing work on the subject the author concludes that the original capacity of a gasoline pipe line can be restored or maintained from the beginning of its operation, if scrapers of the "wire brush and rubber squeegee" (see illustration) type are run through the line at uniform intervals of every three or four days. Not more than four days should elapse between running of scrapers, because a greater time permits the accumulation of so much scale and débris that the scraper may pile up the material ahead of it and plug the line. Running the scrapers at these frequent intervals makes possible the smooth and continuous movement of the scraper without interruption. Whether this process has any effect upon the actual rate of interior corrosion has not been proved. Some engineers believe that the scrapers increase the rate of interior corrosion by constantly exposing fresh surfaces to new attacks, whereas others believe that persistent and frequent removal of the water causes abatement of the corrosion rate.

CHEMISTRY

Determination of Types of Sulfur Compounds in Petroleum Distillates—John S. Ball, in BUREAU OF MINES, REPORT OF INVESTIGATION No. 3591. December 1941; 60 pages.

This paper, amounting to a monograph, is an outline of a system for the analysis of petroleum distillates for groups of sulfur compounds. The system was developed in connection with investigations on the more economic utilization of the so-called "black oils" of Wyoming, and the paper corresponds to a laboratory manual for the determination of amounts and kind of sulfur in straight run gasolines, although it is said that worthwhile results may be obtained on cracked distillates in this boiling range and on kerosenes if the limitations of the system are recognized. The directions and discussion are quite detailed. The system provides for determination of hydrogen sulfide, free sulfur, mercaptans, disulfides, aliphatic sulfides, aromatic sulfides and thiophenes. A distinction in properties has been shown to exist between aromatic and aliphatic sulfides, and the former are placed with the thiophenes rather than with aliphatic sulfides.

Determination of Mixed Aniline Points of Hydrocarbon Solvents—B. H. Shoemaker and J. A. Bolt, before PETROLEUM DIVISION, AMERICAN CHEMICAL SOCIETY, Atlantic City, September, 1941.

The mixed aniline point is a convenient and simple test method for evaluating the solvent properties of petroleum high-solvency naphthas. The definition of the diluent used in determining the mixed aniline point includes any naphtha whose aniline point is 60° C. Data are presented to show that widely different results are obtained in the determination of mixed aniline points of various grades of high-solvency naphthas and of C. P. toluene when using two diluents of different boiling ranges with aniline numbers of 60° C. The definition of the diluent is too broad and it is suggested that the diluent used be identified not only by its aniline point but also by its mixed aniline point with C. P. toluene.

Analysis of Hydrocarbon Gas Mixtures by Mass Spectrometry—Herbert Hoover, Jr., and Harold Washburn, before CALIFORNIA NATURAL GAS ASSOCIATION, 16th Fall Meeting, Los Angeles, 1941.

A short time ago the authors of this paper invented a method for applying the mass spectrometer to an analysis of certain gas mixtures. In the present paper they present some results obtained with this instrument which show that the new method is of considerable interest and importance.

To begin with, the mass spectrometer is an instrument for sorting molecules according to their weight or mass and then measuring the relative number of molecules of each size in the mixture that is being analyzed. In principle, the operation of the instrument is very simple. The mixture of hydrocarbon gases is introduced at one end of a glass vacuum tube which is in the form of a semicircle. As the molecules enter the tube they are given an electric charge so that they can be ionized and moved by the combined action of electric

and magnetic fields. Being thus electrified the molecules enter the analyzer tube where a magnetic field causes the heavier ions to follow a circular path of a greater radius than the lighter ions. In other words, the ionized gas molecules are sorted in the tube according to size. In this way the ions of each side (mass) are caused to fall successively on an electrical collector where they give up their electrical charge. The resulting record shows the relative numbers of ions of each mass which appear at the collector. The composition of the gas mixture can be computed.

Three years' use of this instrument have indicated its uses. It may be some time before instruments can be made available for routine purposes in refineries. The first and most immediate of these purposes will probably be the control of the fractionating operations of depropanizing, debutanizing and deisobutanizing, where the main item of interest is the amount of isobutane being carried off. It is possible to estimate this constituent within a maximum error of only 0.2 percent; the maximum error in determining any of the three constituents is 1.3 percent.

Analyses of this kind are becoming of importance on account of the growing demand for relatively pure propane and butane, which are required as the starting points of new synthetic chemical processes. Many of these processes also require the analysis of mixtures containing olefins (as in alkylation, etc.); estimating olefines in gas mixtures by existing methods is laborious and time-consuming. A complete analysis of the C_4 fraction, including the saturated butanes and the butenes, by the mass spectrometer is now possible. Only a small quantity of the gas mixture is needed, and it is possible to make five to 15 analyses a day, depending on the information desired and the complexity of the mixture. This should be of considerable advantage in refinery control.

Composition of Catalytically Cracked Gasoline—J. R. Bates, S. S. Kurtz, Jr., F. W. Rose, Jr., and I. W. Mills, before PETROLEUM DIVISION, AMERICAN CHEMICAL SOCIETY, Atlantic City, September, 1941.

Since the advent of commercial catalytic cracking of petroleum to produce gasoline there has been much speculation as to the reason for the high octane number of this material as a motor fuel over fuels produced by thermal cracking, and over those occurring in nature as straight-run gasolines. The work presented here shows that this is due to the presence of an overwhelming excess of isoparaffins over normal paraffins in the lower boiling portions of the gasoline and to a high content of aromatic compounds in the higher boiling fractions. The olefin content of catalytic gasolines can be varied widely, with only a secondary effect on fuel quality.

Determination of the Aniline Point of Dark Petroleum Oils—Bruce B. Carr and M. S. Agruss, before PETROLEUM DIVISION, AMERICAN CHEMICAL SOCIETY, Atlantic City, September, 1941.

An inexpensive apparatus is described for determining the aniline point of oils darker than 8 ASTM color. The method developed is based on the visual observation of a thin film formed on the glass wall of the apparatus. Temperatures are obtained by means of a triple junction copper-constantan thermocouple cemented to the inner wall of the apparatus and either a millivoltmeter or potentiometer is used which is calibrated to 0.1 millivolt in the range 0 to 15 millivolts. An accuracy of ± 0.5° F. in aniline point can be easily attained if the apparatus is carefully calibrated.

An Oil Corrosion Tester—Neil MacCoull, E. A. Ryder and A. C. Scholp, before SOCIETY AUTOMOTIVE ENGINEERS, DETROIT, MEETING, January, 1942.

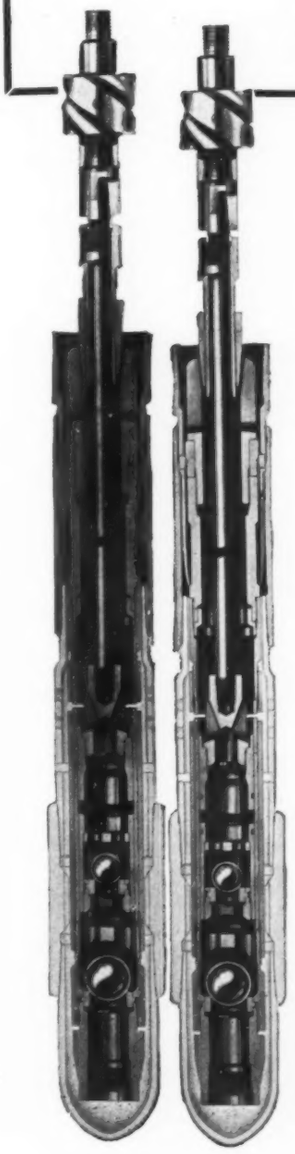
The paper describes a simplified apparatus for testing the corrodibility of bearings on the one hand and the corrosiveness of lubricants on the other hand.

The apparatus and the method of testing are therefore of interest to engine manufacturers who want to choose resistant alloys for bearings, and to oil refiners who offer lubricants of low corrosivity.

The test is based on the principle that the action of an oil on a bearing metal at a high temperature for a short time will be more or less directly proportional to the action at a low temperature for a longer time. The real test is of course given by the engine, but the shortened test will give valuable preliminary information.

The test as originally developed in the laboratories of The Texas Company, consists in placing a sample (125 grams) of the lubricant in a glass beaker; this beaker is immersed in oil (for heat transmission) contained in a somewhat larger beaker which in turn is set in a hole in a solid aluminum block that is heated electrically. A small cylinder of the bearing metal is attached to a vertical spindle that can be rotated at 3,000 r.p.m. When the temperature of the oil sample has been raised to the test temperature (which may be 300° C.) the bearing is lowered into the oil, and rotated for two hours. During rotation air becomes intimately mixed with the hot oil. At the end of the

These AXELSON PUMPS insure economical pumping under tough conditions



Axelson R.S.L. rod type pumps are built to give economical satisfaction under tough conditions. By casting liners *in its own foundry*, Axelson is able to maintain rigid product control from laboratory through every manufacturing operation. You can be sure that "hard metal" liners and other parts in Axelson R.S.L. pumps are rigidly tested for uniformity and quality of all material.

Use of the double end Barnwell plunger, which incorporates an inwardly-beveled lip, prevents sand from getting between plunger and liner because it has a wiping action on both the down and up-stroke. This double action causes plunger to *drop quicker in heavier oil.*

The Perry valve on the plunger reduces gas lock to a minimum by allowing closer spacing of valves. It is also an excellent sand valve due to its streamline effect, thereby creating a greater velocity through plunger.

If you have a particular pumping job, it will pay you to call an Axelson representative now! They make a pump to fit every requirement!

AXELSON MANUFACTURING CO.
6160 Boyle Avenue (P.O. Box 98, Vernon Station)
Los Angeles, California
St. Louis New York Tulsa, Okla.

AXELSON 50th YEAR 1892 1942

AXELSON
SELLS AND SERVICES DEEP WELL PLUNGER PUMPS AND SUCKER RODS

G. A. WELDING *Shop Notes*

CAMERA FIENDS

Photography has a big responsibility in the Plate and Welding Division of General American Transportation Corporation. Many essential tests are made with X-ray and photomicrographic equipment. G. A. laboratory technicians use pictures, too, in the continuous research to keep "Fluid-Fusion" Welded Vessels always the leaders for strength, efficiency, service.

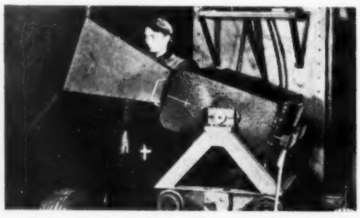


PLATE AND WELDING DIVISION

GENERAL AMERICAN TRANSPORTATION CORPORATION

GATX GENERAL AMERICAN

PLATE & WELDING DIVISION

PLANT AT SHARON, PA.

Cable Address
GENTANWELD
Sharon, Pa.

Offices In All Principal Cities

specified time the bearing is removed, cleaned and weighed. The loss of weight represents the corrodibility of the metal and also the corrosiveness of the oil on such metal.

The reproducibility of the results is about the same as with engine tests. The laboratory test therefore furnishes a research tool for weeding out oils so that engine testing may be reduced to a minimum.

Methods of Light Hydrocarbon Analysis—J. J. Savelli, W. D. Seyfried and B. M. Filbert, in INDUSTRIAL ENGINEERING CHEMISTRY, ANALYTICAL EDITION, Vol. 13 (1941), No. 12, pp. 868-879.

In recent years, the various light hydrocarbons have assumed an increasingly important role as raw materials and there is every indication that this trend will continue. The application of conversion and polymerization processes for the production of gasoline stocks has been a prime factor in the demand for certain light hydrocarbon stocks of definite composition. Concurrently with these developments, there has been an increasing interest in the reproducibility and accuracy of methods of analysis for these light paraffins and olefins, especially the group of four-carbon-atom hydrocarbons.

The present work has included studies of a number of the more widely accepted methods of analysis. Where results indicate it to be desirable, the methods were modified. In many cases, the methods were subjected to a theoretical analysis of the maximum accuracy to be expected. Consideration was given to accuracy, reproducibility, simplicity, speed, and economy of materials. Synthetically prepared mixtures were used for the fundamental investigations, and studies were made of methods of sampling and handling the mixtures prior to analysis.

The types of apparatus studied for the fractional analysis of light hydrocarbon mixtures were the automatically controlled Podbielniak column, the modified California Natural Gasoline Association's (McMillan) column, and a modification of the Ward apparatus for the fractionation of light hydrocarbons at reduced temperatures and pressures. In conjunction with the study of these apparatus, a dew-pressure apparatus for the determination of isobutane and *n*-butane in their two-component mixtures was developed. Included in the study of methods for unsaturate analysis were the determination of total unsaturates in gaseous samples by absorption in various reagents and by the McMillan catalytic hydrogenation method, and the determination of isobutene in gaseous samples by absorption in various reagents and by the McMillan anhydrous hydrogen chloride method.

Operating procedures for the various determinations are given in considerable detail.

Determination of Inorganic Salts in Crude Oil—E. P. Rittershausen and R. J. DeGray, before PETROLEUM DIVISION, AMERICAN CHEMICAL SOCIETY, Atlantic City, September, 1941.

The tetraethyl lead extraction apparatus is used to extract the inorganic salts with water. The water extract is titrated for chloride content in conventional manner. The method offers no saving in time for one sample, but with a battery of three extractors the average time per sample is less than that needed for previous methods. Duplicate determinations by one operator check to within 2 lb. of NaCl per 1000 bbls. of crude.

Refinery Engineers

Excellent opportunities for several capable oil refinery engineers, with old established engineering concern. Should have technical education, with a thorough knowledge of refinery equipment and processes. Salary commensurate with experience and capabilities.

Application should be made by letter, giving age, nationality, concise outline of previous business experience and educational background, present salary, salary desired, and references. Include recent photograph.

Ernest Owen, E. B. BADGER & SONS COMPANY, 75 Pitts St., Boston, Mass.

RENOLD

MARK 3

OIL WELL CHAIN

Designed and made to A. P. I. specification by the world's leading driving chain makers.
Send for leaflet No. 216/32
THE RENOLD & COVENTRY CHAIN CO., Ltd.
MANCHESTER, ENGLAND
Agents throughout the world

STORAGE TANKS

any capacity

for OIL, PETROL, ETC.

ARC WELDED

We are experts in the designing, manufacture and erection of Welded Tanks.

COMPLETE INSTALLATIONS

Send us your Enquiries

Oxley Engineering Co., Ltd.
HUNSLET LEEDS, 10 ENGLAND
Telephone LEEDS 27468/9 Telegrams: OXBROS LEEDS
LONDON OFFICE: Winchester House, Old Broad Street, E. C. 2
Telephone: LONDON WALL 3731

7 sound reasons why *You* should use

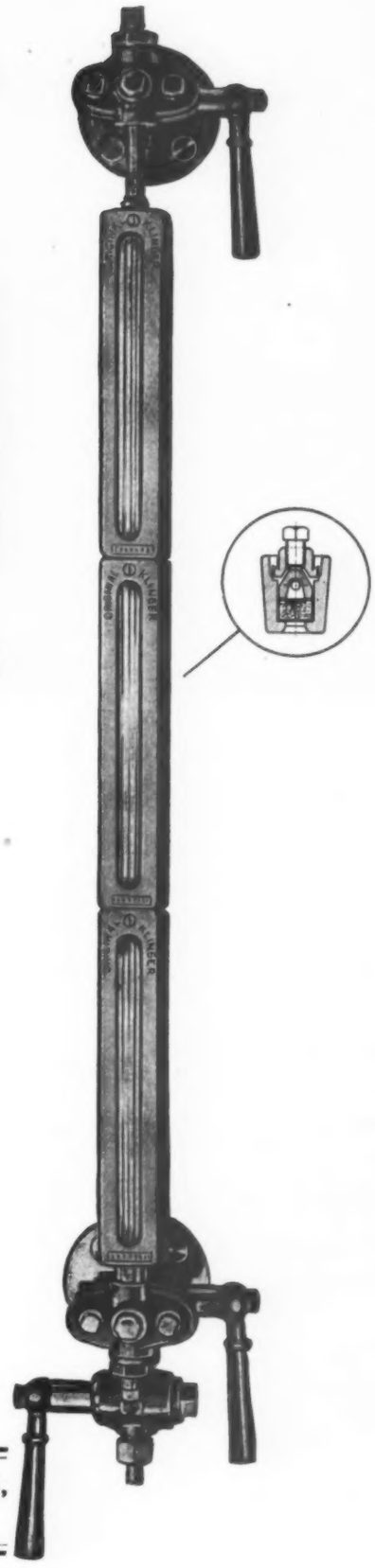
"Klinger

LEVEL INDICATORS

The Reflex Level Indicator illustrated is of forged construction throughout, with stainless steel trim.

Among its special features are :

* Rigid box-shaped Forged Steel Gauge Body.
* Reflex Gauge fitted with one row of tightening bolts only.
* Separate Glasses easily removable.
* Automatic safety shut-off balls at top and bottom.
* Easily detachable stuffing-box heads for removing gauge as complete unit.
* Gauge can be turned to face any direction.
* Klinger patent " SLEEVE-PACKED " shut-off and drain cocks.

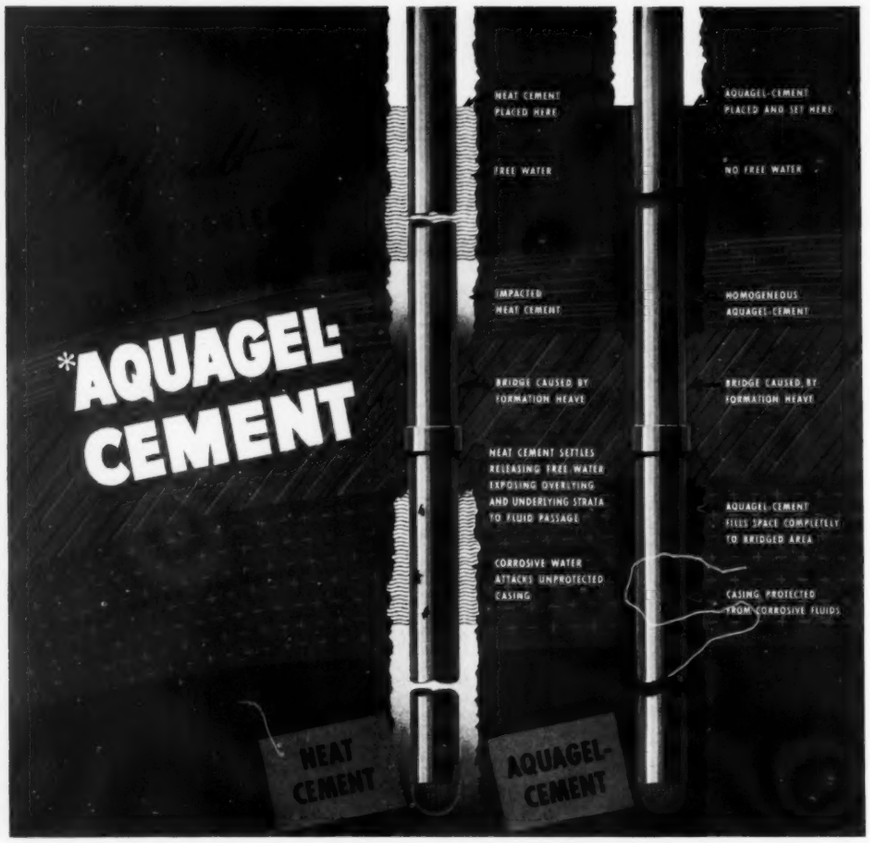


Specialists in all types of LEVEL GAUGES, including Double Plate (Thru'-Vision) Type, Steam Heated Gauges and the Hubbard Patent Gauge for LIQUEFIED GASES (Butane, Propane. etc.).

Write for Catalogue and full particulars

RICHARD KLINGER LTD., "KLINGERIT" WORKS, SIDCUP, KENT, ENGLAND

Foots Cray 3022


*AQUAGEL-CEMENT
NEAT CEMENT PLACED HERE
AQUAGEL-CEMENT PLACED AND SET HERE
FREE WATER
NO FREE WATER
IMPACTED NEAT CEMENT
HOMOGENEOUS AQUAGEL-CEMENT
BRIDGE CAUSED BY FORMATION HEAVE
BRIDGE CAUSED BY FORMATION HEAVE
NEAT CEMENT SETTLES RELEASING FREE WATER EXPOSING OVERLYING AND UNDERLYING STRATA TO FLUID PASSAGE
AQUAGEL-CEMENT FILLS SPACE COMPLETELY TO BRIDGED AREA
CORROSIVE WATER ATTACKS UNPROTECTED CASING
CASING PROTECTED FROM CORROSIVE FLUIDS
NEAT CEMENT
AQUAGEL-CEMENT

Cementing casing, even under the most adverse conditions, can often be successfully accomplished with AQUAGEL-Cement. Illustrated here is one difficult problem which has been solved by this means.

In both wells a heaving stratum has sloughed, forming a bridge around each casing during, or shortly after, running of the cement. Note that the neat cement has settled below the bridge, thus exposing the casing to the injurious attack of corrosive salt water and allowing the harmful transfer of fluids between adjacent strata. The AQUAGEL-Cement, on the other hand, remains in place substantially as set, protects the casing from further sloughing, from the corrosive effects of salt water and prevents the transfer of fluids between adjacent strata.

It pays to use Baroid Products and Service in every well you drill.

PATENT LICENSES, unrestricted as to sources of supply of materials but on royalty bases, will be granted to responsible oil companies and operators to practice the inventions of any and/or all of United States Patents Nos. 1,575,944; 1,575,945; 1,807,082; 1,991,637 and further improvements thereof. Applications for such licenses should be made to Los Angeles office.

*AQUAGEL-Cement, or gel cement as it is commonly known, is any Portland or oil well cement to which has been admixed a small amount of AQUAGEL to keep it from releasing free water or allowing settling, and at the same time to impart to it sufficient gelling properties at the water-cement ratio at which it is to be used.

BAROID SALES DIVISION • NATIONAL LEAD COMPANY

BAROID SALES OFFICES: HOUSTON • LOS ANGELES • TULSA

BAROID PRODUCTS: BAROID AND COLOX, AQUAGEL, FIBROTEX, BAROCO, STABILITE, AQUAGEL-CEMENT, SMENTOX, ZEOGEL, IMPERMEX, MICATEX, TESTING EQUIPMENT, BAROID WELL LOGGING SERVICE

CHEMICO

the leading name in acid plants

Chemico supremacy is based on 27 years of specialized experience in acid production and recovery, unequalled resources and facilities in experimentation and design, and the results obtained in hundreds of installations all over the world. Consult Chemico for either new construction or remodeling of acid plants, whether for large or small requirements.

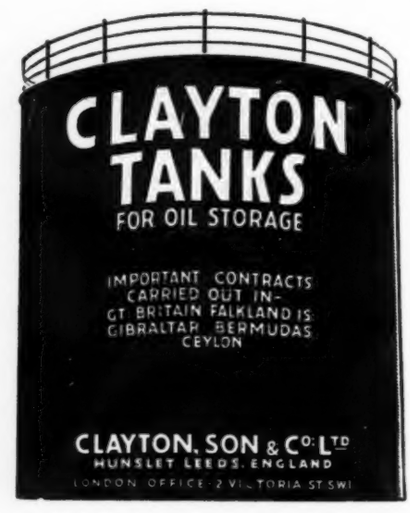
Chemical Construction Corporation

30 Rockefeller Plaza, New York, N. Y.

Cables: Chemiconst, New York

European Representatives, Cyanamid Products, Ltd., Berkhamsted, Herts., England

CHEMICO PLANTS are PROFITABLE INVESTMENTS



PHYSICS

1941 CFR Road Detonation Tests—J. M. Campbell, R. J. Greenshields, W. M. Holaday and C. B. Veal, before SOCIETY AUTOMOTIVE ENGINEERS, Detroit Meeting, January 1942.

This paper is compiled from the report of the Cooperative Fuel Research Committee and relates to further experience with new methods of test including the borderline and modified borderline procedures. Extensive data were obtained on the fuel requirements of the 1940 and 1941 models of the three most popular cars, and on the knocking characteristics of current gasolines representing the bulk of the sales volume in various parts of the United States. Reference fuel frameworks were developed for the tests on the cars used.

It is noted that the value of these reference-fuel frameworks is limited by variations from car to car of the same make. For instance, in nine cars of one make the range of variation of engine speed plotted against spark advance averaged 12 degrees at high and about 4 deg. at low speeds. At either speed, this range is the equivalent of from 8 to 10 octane numbers. This spread is presumably due to a number of causes, such as real differences between engines, and various sources of experimental error. Whatever the causes, these variations between cars have important significance in that they indicate the necessity for the use of statistical methods for the evaluation of the octane requirement of a particular make of car (a test on a single unit of a given model with a given fuel is not conclusive).

In application of this statistical approach the authors present an analysis of tests on 73 cars in relation to their behavior with fuel 41-C. From this analysis it appears that at 750 r.p.m. less than 50 percent of these cars and at 3,000 r.p.m. less than 5 percent will knock on this fuel.

Data were also collected on a number of regular and premium fuels. It is shown that by combining the octane statistics of the fuels with corresponding octane-number data for a given make of car, the probabilities of detonation in various speed ranges may be estimated. This information may be used also in conjunction with reference-fuel frameworks as a guide in the design of distributor characteristics that will conform with fuels currently available. When they are available, of course, corresponding data for a particular car make would be preferable for distributor design. The complete CFR report contains separate figures representing the behavior of "regular" and "premium" gasolines in 1940 and 1941 models of Chevrolet, Ford, and Plymouth. Appraised by this comparison, the average "regular"-grade fuel will be satisfactory—operate without knock—in more than 75 percent of these cars at 1,000 r.p.m. (approximately 20 m.p.h.), and will be equally satisfactory in more than 90 percent of the cars at 3,000 r.p.m. (approximately 60 m.p.h.).

REFINING

Fuel Economies in the Modern Petroleum Refinery—L. A. Meklen, before WESTERN PETROLEUM REFINERS ASSOCIATION, Shreveport Meeting, October, 1941.

Not so long ago one of the problems of the refiner was how to get rid of excess non-salable products. At present that situation is radically changing. The amount of non-salable liquid residues has

STANDARD-VACUUM OIL COMPANY

Producers and Refiners
of Petroleum Products

Distribution and marketing facilities in the Far East, India, Netherlands Indies, Australasia, South and East Africa.

★

EXECUTIVE OFFICES

26 BROADWAY

NEW YORK CITY

been greatly reduced in most refineries. The refinery gases which, because they cannot be stored and are seldom sold, are the main non-salable fuel produced by the refineries at present, and in most refineries the quantity produced is seldom sufficient to finance all of the refining operations and the power requirement. In many cases the refiner now has to burn either something he could sell or something he has to buy. Fuel economies, therefore, become not only of academic interest but a question of real out-of-pocket expense. The refining industry uses approximately 100,000,000 barrels of fuel per year and a saving of 15-20% of that fuel, which is quite possible in most refineries, would amount to over 15,000,000 barrels of equivalent fuel a year, or a possible saving of over $10,000,000 which can be better spent by the refineries than throwing it out through the chimney into the air.

Fuel savings can be made in two ways; first, by burning the fuel properly, and second, by utilizing the heat properly. Proper burning of the fuel includes firing the refinery processes at steady rates and blending gas fuels from different sources before they reach the furnace. With liquid fuels the pressure and temperature of the oil should be controlled so as to maintain a constant delivery to the burners. Another item in proper burning of the fuel is to control the furnace air. Many refineries commonly burn "Bunker C" fuel with 100 percent of excess air. If the excess air were reduced to 50 percent, which is quite easily obtained, this would save up to 10 percent of the fuel used.

In some oil heaters the loss of heat with the flue gases may be as high as 30 percent. Another way to utilize the heat generated from the fuel is to employ the heat in the flue gas to preheat the air entering the furnace.

Within certain limits of possible savings, air preheat and reduction of excess air are interchangeable and the savings obtained by both are cumulative. For example, a reduction of excess air from 100% down to 30% will give the same savings (17.5%) as would be obtained with 100% excess air if the air were preheated to 475° F. The combined savings of the excess air reduction and the air preheat would be approximately 26.5%.

There are two types of air preheaters—the recuperative and the regenerative, which are available in various forms. Among the least expensive is the

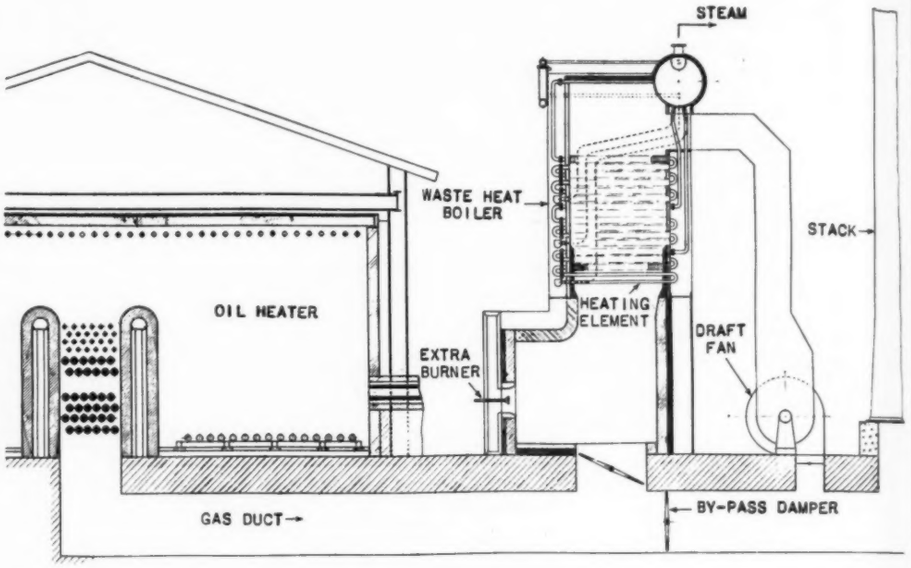
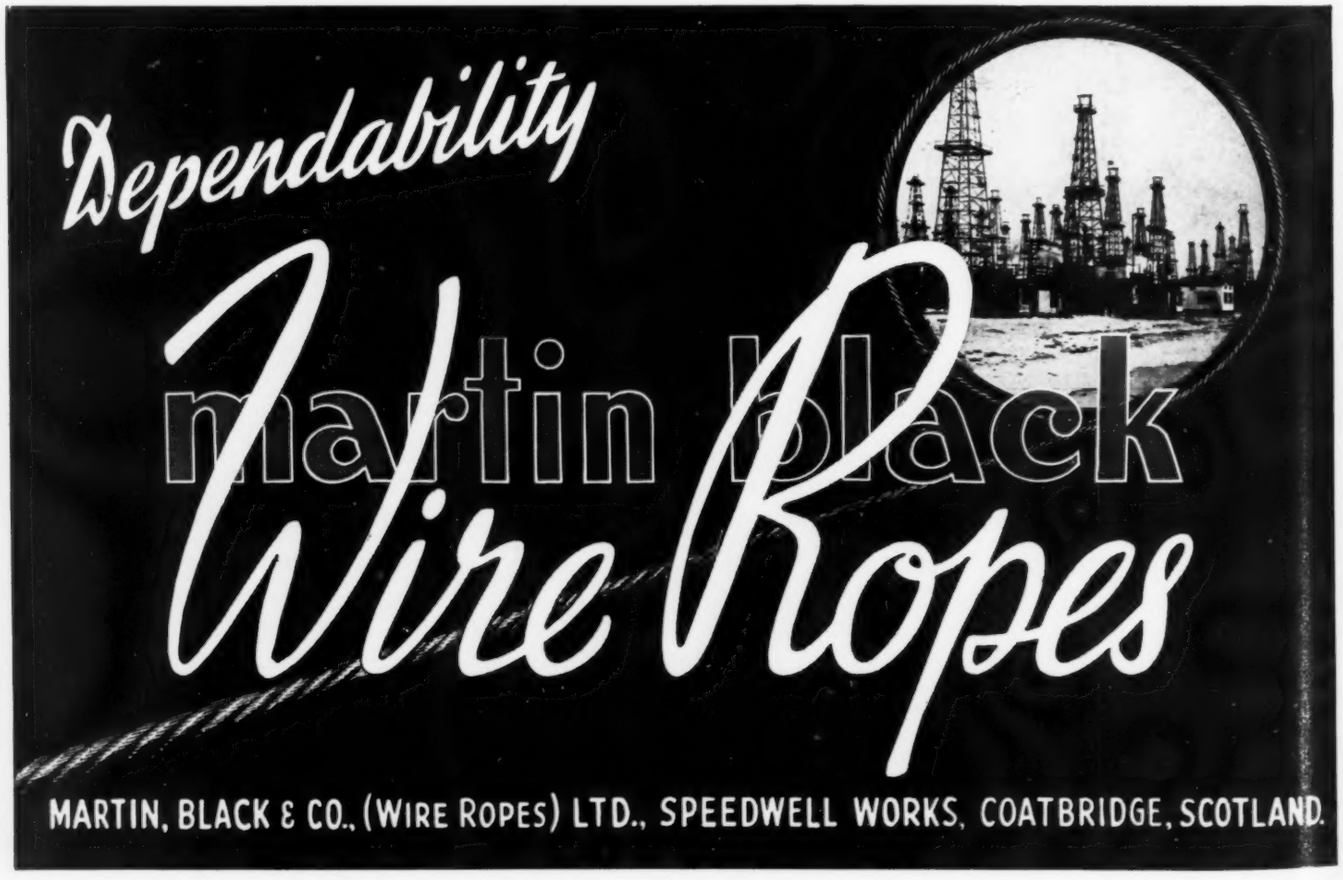


Figure shows a cross section through a waste heat boiler installed on an oil heater. Provisions to burn auxiliary fuel are made in this installation.



tubular air preheater; the most expensive is the natural draft air preheater. However, after its pay-off the natural draft preheater will produce much more savings per year. Incidentally, the cost of the preheater alone is seldom more than half of the total cost of the installation.

The heat content of the flue gases leaving the petroleum heater can also be recovered in waste heat boilers for regeneration of steam. The heating elements for the waste heat boiler may be arranged as an additional bank in the so-called convection section of the heater, or it may be arranged in a separate structure.

High Temperature Alkylation of Aromatic Hydrocarbons—A. N. Sachanen and A. A. O'Kelly, in INDUSTRIAL ENGINEERING CHEMISTRY, Vol. 33 (1940), No. 12, pp. 1541-1544.

This research points a way to obtain some new blending materials for high octane number gasoline. Aromatic hydrocarbons—e.g., benzene and toluene—have been alkylated with olefins at high temperatures of 800° F. and above. This process was performed under atmospheric pressure and in the absence of catalysts, but high pressures and such catalysts as activated clay improved the yields of alkyl aromatics. Toluene is more easily alkylated than benzene at these temperatures. On the other hand, propylene and butylene are stronger alkylating agents than amylene.

Under high temperatures the alkyl aromatics produced were partially cracked, forming alkyl aromatics of a lower molecular weight. As a result, alkyl aromatics formed were composed of an entire series of aromatics beginning with toluene and increasing in molecular weight. The alkyl aromatics produced contained 90 per cent or more of purely aromatic hydrocarbons.

A 50-50 mixture of casing-head gasoline (ep. 318° F., motor octane number, clear, 65.3) and alkyl aromatics plus 3 cc. TEL had an octane number of 95.3 and a blending value of 101.5.

The high-boiling or solvent cut of alkyl aromatics may be employed for improvement of octane number of motor gasolines, since its octane blending value is 2-3 units higher than that of the aviation cut. On the other hand, this solvent fraction may also be employed as solvent naphtha of very high solvent power. Furthermore, cracking of this so-called solvent fraction results in lower boiling aromatics which may be used in the aviation cut.

This solvent material consists chiefly of propyl-, butyl-, and amylbenzenes. The total amount of unsaturates does not exceed 5 percent by volume.

USES

A Cetane-Number Study of Diesel Oils—W. G. Aimsley, H. D. Young, and M. L. Hamilton, before SOCIETY AUTOMOTIVE ENGINEERS, FUELS AND LUBRICANTS meeting, Tulsa, October, 1941.

Among Diesel engineers, the modern high-speed Diesel is taking a definite place as a dependable, efficient and economical source of power.

While retaining all advantages of safety and economy, these high-speed designs demand a fuel that has been more carefully selected and more critically controlled than the usual run of Diesel fuels, with particular reference to ignition quality. The rating of this quality thus figures prominently in the inspection of these fuels.

After surveying methods for determining the cetane rating of Diesel fuels, it is concluded that the refiner is not in a position to meet a wide variety of Diesel fuels, and that if consumers want a low cost fuel, and wish to be relieved of the difficulties traceable to wide variations between the products of various refineries, they should limit their demands to something that will be satisfactory and which the refiner can produce and sell economically.

They therefore limit their recommendation to Diesel

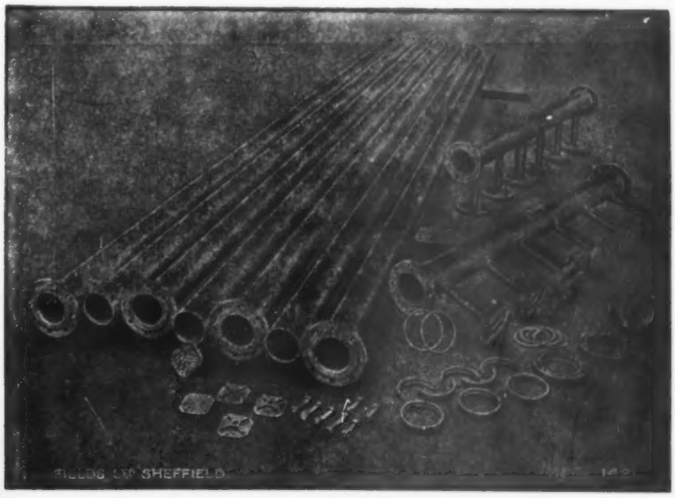
A.S.T.M. Diesel Fuel Classification (Grade 2-D)

(Report of A.S.T.M. D-2 Committee for 1941)

Flash, Min., (°F.)	140
Pour, Max., (°F.)	20a
BS & W, Max., (%)	0.05
Carbon Residue (10% Btms) Max., (%)	0.20
Ash, Max., (%)	0.01
ASTM Distillation,	
90% Point, Max., (°F.)	650
End Point, Max., (°F.)	700
Viscosity,	
Kinematic, (Centistokes)	2.0 Min., to 6.0 Max.
Saybolt, (SSU)	32.6 Min., to 45.6 Max.
Sulphur, Max., (%)	1.0
Corrosion	Pass
Alkali and Mineral Acid	None
Cetane Number, Min.	45.0

a—Lower pour points may be specified whenever required by local temperature conditions to facilitate storage and use. When operations are anticipated at atmospheric temperatures below an average daily minimum of +10°F., lowering the pour point may also require a lowering of the minimum viscosity limit.

HIGH QUALITY
STEELS
FOR THE OIL INDUSTRY.
TRADE ERA MARK
H.R.
HEAT-RESISTING STEELS
HAVE NUMEROUS APPLICATIONS.
For parts of plant requiring rigidity and low scaling loss at high temperatures they are unequalled.
TRADE ERA MARK
C.R.
NON-CORRODING STEELS
FOR THERMOWELLS, REACTION VESSELS, PUMP PARTS, BUBBLE CAPS.
Highly resistant to the attack of numerous chemical agents.



REFORMER OVEN TUBES AND FITTINGS OF HADFIELDS "ERA H.R." HEAT-RESISTING STEEL. FABRICATED FROM ROLLED PLATES AND WELDED TOGETHER. LENGTH OF TUBES 24 FEET 1⅜ INCHES. INSIDE DIAMETER 6 INCHES.

HADFIELDS LTD.
EAST HECLA WORKS • SHEFFIELD • ENGLAND.

No. 2517

fuel 2-D of the A.S.T.M. classification of Diesel Fuels (Report of Committee D-2-1940) as a universal Diesel fuel suitable for mobile and high-speed equipment. Specifications for this fuel are given in the accompanying table.

BOOKS

Oil Well Drainage—by Stanley C. Herold, Published 1941 by STANFORD UNIVERSITY PRESS, Stanford University, California, 407 pages 7 x 10¼ inches, $5.00.

After the drill has struck oil the principal business of the owner of the well is to get the oil out. There is generally only one right way to manage an oil pool, but there may be numerous wrong ways. Complete or at least satisfactory recovery will depend on choosing the right and avoiding the wrong. Producing an oil pool really means draining the oil out of the sand, or whatever formation it is in. The well itself is simply an opening toward which the oil may reach the surface. What makes the oil move, and how is its movement controlled, affected or limited by its own nature and by the physical and geological circumstances under which it is placed? And how do these circumstances affect recovery and conservation? These are questions that concern not only the production engineer to whom has been assigned the task of getting the oil out; they touch the direct and the remote interests of the operator who has to pay out his investment, the lease-holder who expects royalties, the landowner who has property rights at stake, the attorneys at law and the legal experts who have suits to win and contracts to enforce, the politicians who draft legislation and the government officials who are responsible for the conservation of the national patrimony.

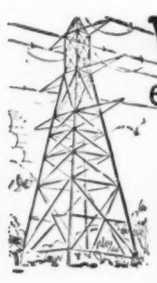
The author of this book has set out to explain oil well drainage to these various categories of interested persons and it may be said at once he has made an understandable job of it. Dr. Herold has already become well known through his wide-ranging career as a petroleum geologist and production engineer and through his work: "Analytical Principles of the Production of Oil, Gas and Water from Wells," published some 12 years ago. That work was mostly a mathematical exposition of the physical principles of well drainage. In the present work he eschews all mathematics and shows how the fundamental principles have worked and are now working to deliver oil to the operators, f.o.b. well. He takes his examples from typical fields of the United States and shows how the circumstances in these fields exemplify the basic principles which all persons interested in oil should understand. In this way he successively illustrates the natures of the underground reservoirs, the energy of reservoirs, the function of gas, regional drainage and water encroachment across property lines, stratigraphy and structure, reservoir penetration, multiple zones, rates of production, field development, oil content, secondary and ultimate recovery and reserves, abandonment, curtailment, proration and conservation. All this is set forth in simple language that should be easy reading for the average intelligent layman.

The reader is further helped by a device which can be recommended to other authors who write for laymen. On the margin of the page alongside every paragraph is a brief sentence which summarizes the gist of that paragraph, so that the reader may readily carry on the thought. Another device which helps to rivet the reader's attention on essentials is the thoroughgoing distinction that is made between what are commonly known as water drive and gas drive. Dr. Herold is dissatisfied with these two terms as commonly understood, because they fail to include the whole situation to which they are supposed to refer. Instead he employs the terms "Cenozoic drainage" and "Paleozoic drainage" and never omits to point out that they designate phenomena that are completely and everlastingly exclusive one of the other. Every chapter, e. g., the chapter on "regional drainage and water encroachment," is divided into two parts, one expounding situations where Cenozoic drainage, (waterdrive) is controlling and the other where Paleozoic, (gasdrive) is involved.

Some professional petroleum technologists may think that Dr. Herold has waded far out into certain controversial matters, but there can be no disputing the fact that he has produced a book of immense value to the categories of readers to whom it is addressed.

Annual Reviews of Petroleum Technology, Vol. 6 (covering 1940)—by F. H. Garner; Published 1941 by INSTITUTE OF PETROLEUM, Birmingham, England. Paper, 318 pages; 11S. or $2.50.

This valuable publication carries on in spite of the disturbed condition of the world. Naturally, much of the research and development in the



Wherever there is electrical equipment —

The 46-RANGE UNIVERSAL

AVOMETER

Electrical Measuring Instrument Model 7

46 RANGES ONE INSTRUMENT

Current, A.C. and D.C. (0 to 10 amps.)
Voltage, A.C. and D.C. (0 to 1,000 volts.)
Resistance (up to 40 megohms.)
Capacity (0 to 20 mfds.)
Audio-frequency Power Output (0 to 4 watts.)
Decibels (—10 Db. to +15 Db.)

Because of its outstanding versatility, accuracy and simplicity the Model 7 Universal AvoMeter is the most widely used of all test meters. A compact multi-range A.C./D.C. instrument, it provides for 46 ranges of direct readings covering every essential electrical test. No external shunts or multipliers. All measurements made from two terminal points only—selection of any range by means of two simple switches. B.S. 1st Grade accuracy. Automatic cut-out protects meter against severe overload. Robustly built for lasting, reliable service.

BRITISH MADE

In spite of greatly increased production, most of our output of "AVO" Instruments is being taken by the Services. Delay in delivery of Trade Orders is consequently inevitable, but we shall continue to do our best to fulfil your requirements as promptly as possible.

• *Write for fully descriptive literature and current prices.*

Sole Proprietors and Manufacturers:—
THE AUTOMATIC COIL WINDER & ELECTRICAL EQUIPMENT CO., LTD.
Winder House, Douglas Street, London, S.W.1, England. *Telephone: Victoria 3404-7*

CROSSLEY

HIGH SPEED DIESEL ENGINES

LOCOMOTIVE ENGINES
COMBINED SETS
AUTOMATIC SETS
MARINE AUXILIARY SETS
MARINE PROPULSION SETS

Crossley Diesel Engines Range— 3 to 3,000 B.H.P.

SIZES — 12 B.H.P. TO 120 B.H.P.

Users of Crossley engines know that they can place every confidence in their performance. More than ever to-day in many spheres of activity they are employing the Crossley Vertical High Speed Diesel.
The engines incorporate the rugged properties of a heavy-duty engine, are light in weight, and yet of rigid construction. Cold starting is certain and immediate.

55 kw. Crossley fully automatic generating set for marine or land duties.

CROSSLEY BROTHERS LTD. MANCHESTER 11.
LONDON OFFICE, 2 HOWARD ST. W.C.2

C206

petroleum industry since 1939 has not yet found its way into print, and due to interruption of communications it has obviously been difficult to approximate a complete record. Nevertheless, the editor has produced an annual review that suffers little from a comparison with previous ones, even though reviews on some subjects could not be completed by the authors to whom they were assigned. The 18 chapters include the following: petroleum geology, regional geology and development in the United States, drilling and development in U.S.A. fields, production engineering, production, transportation and storage, natural gas, liquefied petroleum gases and natural gasoline, chemical and physical refining, cracking, alternative fuels (low and medium temperature carbonization, fuels produced by hydrogenation and synthetic processes) motor benzole, analysis and testing; gas, diesel and fuel oils, asphaltic bitumen and road materials, special products, petroleum literature in 1940, petroleum statistics, lubricants and lubrication, with the usual full indexes.

Index to A.S.T.M. Standards Published December, 1941—by AMERICAN SOCIETY TESTING MATERIALS, Philadelphia, 196 pages; gratis.

This publication is essential in using the Society's Book of Standards, including the 1940 and 1941 supplements. It will be of particular service to those who wish to know whether the A.S.T.M. has issued standard specifications, test methods or definitions covering a particular engineering material or subject. A list is given of the 1043 specifications and tests in numeric sequence of their serial designations. All items are listed under appropriate key words.

GENERAL

Natural Gasoline and National Defense— Paul M. Raigorodsky before CALIFORNIA NATURAL GAS ASSOCIATION, 19th Annual Fall Meeting, Los Angeles, 1941.

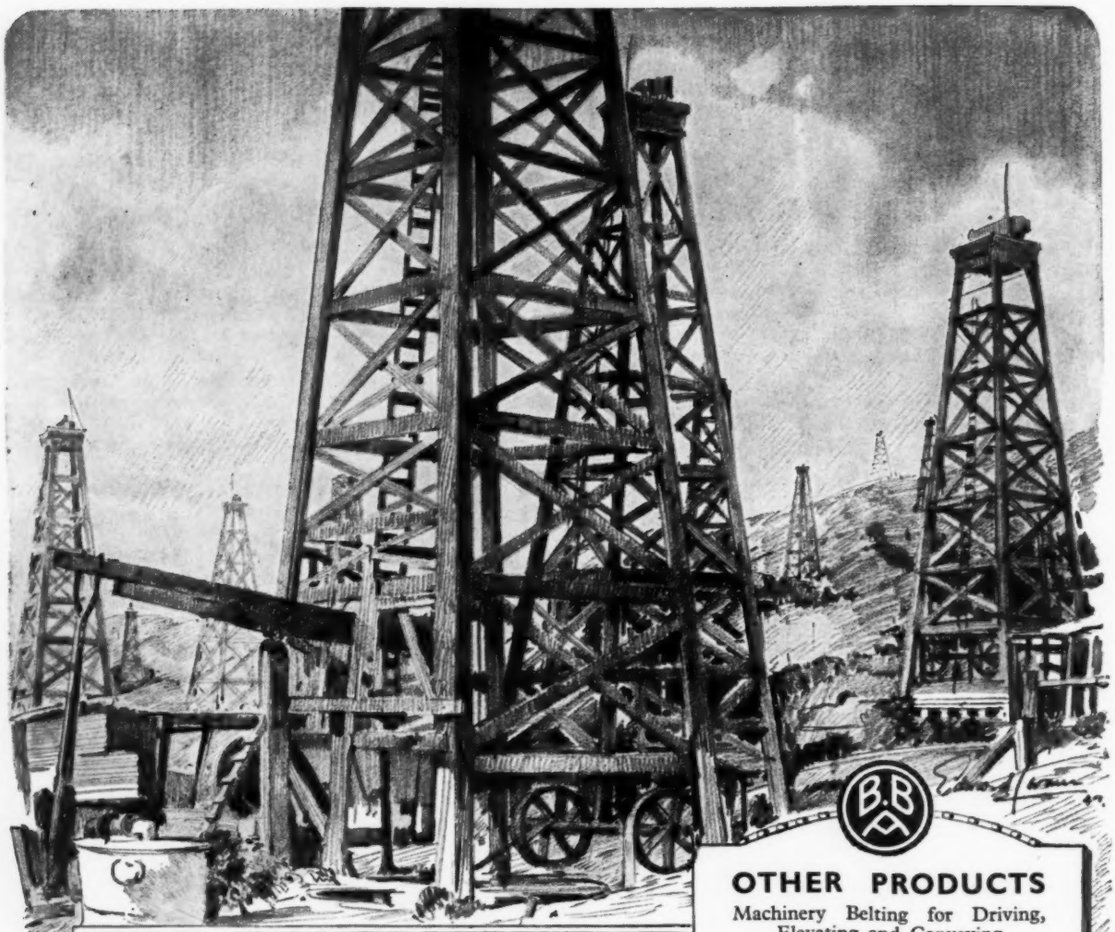
Today's production of about 165,000 bbl. of natural gasoline represents nearly 10 percent of the total production of gasoline in the United States. It would require 7,000 wells, each producing 40 bbl. a day, to produce the 275,000 bbl. of crude oil needed to displace this amount of natural gasoline and this only if the highest known refining yield were obtained. Drilling these 7,000 wells and building the necessary refineries would cost a quarter of a billion dollars.

Much natural gasoline is used for blending to produce high octane motor fuel. If all available natural gasoline were used for this purpose the gasoline manufacturers would save about 10 million cc.'s of tetra ethyl lead a day. From an overall national standpoint this would represent a substantial release of essential chemicals without deterioration of present gasoline quality.

The requirements of national defense are increasing the use of butane and are making room for the use of propane as a fair substitute for the previous uses of butane. Obtaining the butane needed for the manufacture of isobutane by complicated and expensive conversion processes at the refineries will be much more costly and time-consuming than to build more facilities for the processing of casinghead. Much can still be done without new construction. It is tentatively estimated that over 35,000 bbl. of butane can be made available in the natural gas industry for dehydrogenation or isomerization without substantial expenditure on facilities for its production. This volume, combined with available isobutane, would produce almost 50,000 bbl. of alkylate of 94 octane, which with aviation straight-run of 70-74 octane and 3 cc. of lead would produce 80,000 bbl. a day of 100 octane aviation gasoline.

Deposition of Free Oil by Sediments Settling in Sea Water—O. A. Poirier and George A. Thiel, in BULLETIN AMERICAN ASSOCIATION PETROLEUM GEOLOGISTS, Vol. 25 (1941), No. 12, pp. 1270-1280.

A new approach to the problem of the origin of oil and source beds of petroleum is made by an experimental study of the deposition of oil as a sediment. Oil dispersed in a mixture of fine-grained sediment and sea water will settle and be trapped on the bottom by the sediment. Experimental observations are made on the oil-settling characteristics of a series of 10 different sediments, which represent a wide range of possible source beds of petroleum. Comparative results of the volume of oil that one gram of each sediment can completely carry down and trap in an oil sediment-sea water mixture are tabulated. This volume of oil deposited varies considerably throughout the series of sediments studied, and is generally found to be inversely proportional to the size of the mineral grains. Microscopic examination of the oil sediment shows that the oil is carried down by the weight of mineral grains adhering to the globules.



OTHER PRODUCTS

Machinery Belting for Driving, Elevating and Conveying
Vee-belts,
Endless Belts for Short-centre Drives
Asbestos
Yarns, Cloths and Tapes

Wherever quality can ensure efficiency, safety and reliability you may expect to find B.B.A. Products—a general statement which goes a long way to explaining the demand for B.B.A. Asbestos in the petroleum world, where you will, in fact, find :

"PHŒNIX" PACKINGS.—For all services and pressures, Steam, Hydraulic, Oil, Acid Alkali resisting, etc.

"PHŒNIXITE" JOINTING.—Cross-laminated to resist pressures from all directions, for Steam, Superheated-Steam, Acids, Alkalis, Gases, Water, etc.

(Petrol and Oil Resisting Jointings are a speciality.)

"MINTEX" FRICTION LININGS.—For Winding Gears, Tractors, Scoops, Cranes, Trucks, Aircraft and Cars of all Types.

BRITISH BELTING & ASBESTOS LIMITED

CLECKHEATON :: YORKSHIRE :: ENGLAND